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THE

TWELFTH ANNUAL REPORT

OF THE

AMERICAN RAILWAY

MASTER MECHANICS' ASSOCIATION,

IN CONVENTION AT CINCINNATI,

MAY 13TH, 14TH, AND 15TH, 1879.

CINCINNATI:
WILSTACH, BALDWIN & CO.,
RAILWAY PRINTERS AND MANUFACTURING STATIONERS.
1879.

REPORT.

CINCINNATI, May 13, 1879.

The American Railway Master Mechanics' Association convened at the Grand Hotel, in the City of Cincinnati, at 9 o'clock, A. M.

PRESIDENT, N. E. CHAPMAN, in the Chair, and the following officers present:

R. WELLS, Jeffersonville, Madison & Indianapolis Railroad, First Vice-President.

S. J. HAYES, Illinois Central Railroad, Treasurer.

J. H. SETCHEL, Little Miami Railroad, Secretary.

Convention was called to order, and the proceedings opened with prayer, by the Rev. D. F. Harris, of Columbia Congregational Church.

An address was made by Col. L. M. Dayton, who extended the hospitalities of the city as Cincinnati's welcome to her guests.

THE PRESIDENT—Gentlemen, the minutes of the last annual meeting have been printed in pamphlet form, and each member of the Association has been provided with a copy. It has been our custom to accept these minutes without reading. What is your pleasure in regard to it?

MR. HAYES, Illinois Central Railroad—I move the minutes be received without reading.

Carried.

THE PRESIDENT—The next business in order is the calling of the roll. The Secretary will please call the roll.

The Secretary then called the roll, and 58 members answered to their names.

MEMBERS PRESENT AT ROLL CALL.

NAME.	ROAD.	ADDRESS.
ANDERSON, H	No. 147 Randolph street	Chicago, Ill.
BROOKS, H. G	Brooks Locomotive Works	Dunkirk, New York.
BLACK, JOHN	Dayton & Michigan	Lima, Ohio.
CHAPMAN, N. E	Cleveland & Pittsburgh	Cleveland, Ohio.

NAME	ROAD.	ADDRESS.
COOPER, H. L.	Indianapolis, Bloomington & Western	Urbana, Illinois.
CORY, CHARLES H.	Central Railroad of Iowa	Marshalltown, Iowa.
COON, GEO. F.	Mineral Range	Hancock, Michigan.
DEVINE, J. F.	Wilmington & Weldon	Wilmington, N. C.
ELLIOTT, HENRY		St. Louis, Mo.
ECKFORD, JAMES	Cincinnati, Hamilton & Dayton	Cincinnati, Ohio.
FLYNN J. H.	Western & Atlantic	Atlanta, Ga.
FULLER, WILLIAM	Atlantic & Great Western	Meadville, Pa.
FOSTER, W. A.	W. Division, Fitchburg	Fitchburg, Mass.
GRAHAM, CHARLES	Lackawanna & Bloomsburg	Kingston, Pa.
HAYES, S. J.	Illinois Central	Chicago, Illinois.
HEWITT, W. O.	Toledo, Peoria & Warsaw.	Peoria, Illinois.
JOHANN, JACOB	Wabash	Springfield, Illinois.
KAUFHOLZ, F. G.	Cleveland Columbus, Cin'ti & Ind	Cleveland, Ohio.
KING, ROBERT	Western of Alabama	Montgomery, Alabama.
MINSHALL, J.	New York & Oswego Midland	Middletown, N. York.
McKENNA, J.	Indianapolis, Peru & Chicago	Peru, Ind.
McVAY, JOHN	Alabama & Chattanooga	Chattanooga, Tenn.
ORTTON, JOHN	Canada Southern	St. Thomas, Canada.
PRESCOTT, G. H.	Pittsburgh, Cincinnati & St. Louis	Logansport, Ind.
RICHARDS, GEORGE	Boston & Providence	Boston, Massachusetts.
REYNOLDS, G. W.	Boston, Clinton, Fitchburg & N. B.	Taunton, Mass.
SETCHEL, J. H.	Little Miami	Cincinnati, Ohio.
SEDGLEY, JAMES	Lake Shore & Michigan Southern	Cleveland, Ohio.
SPRAGUE, H. N.	Porter, Bell & Co.	Pittsburgh, Pa.
SALISBURY L. B.	St. Louis & South Eastern	Mt. Vernon, Ill.
SELBY, W. H.	St. Louis, Kansas City & Missouri	Moberly, Mo.
SIMONDS, G. B.	Cairo & St. Louis	East Carondelet, Ill.
SWIFT, JOHN	Schenectady Locomotive Words	Schnectady, New York.
TULL, C. H.	Vicksburg, Shreveport & Texas	Monroe, La.
WIGGINS, J. E.	Houston, East & West Texas	Houston, Texas.
WHITE, J. L.	Evansville & Crawfordsville	Evansville, Ind.
WHITE, PHILIP	Cleveland & Pittsburgh	Wellsville, O.
LILLY, J. O. D		Indianapolis, Ind.
MILES, F. B.		Philadelphia, Pa.

THE PRESIDENT—The Secretary will please read Article IV of the Constitution.

The Secretary then read Article IV of the Constitution.

THE PRESIDENT—Gentlemen, an opportunity is now given for those who

are qualified and desire to become members. It has been our custom to take a recess of a few minutes, to allow those who wish to do so to sign the Constitution.

NEW MEMBERS.

NAME.	ROAD.	ADDRESS.
BALDWIN, B. L	Paris & Danville	Danville, Ill.
BISSETT, JOHN	Cheraw & Darlington	Florence, S. C.
BRIGGS, R. H	Mobile & Ohio	Whistler, Ala.
COOK, JNO. S	Georgia	Augusta, Georgia.
COOK, ALLEN	Chicago & East Illinois	Danville, Ill.
GREGG, B. J	Cincinnati, Sandusky & Cleveland	Sandusky, Ohio.
GORDON, JAMES T	Concord	Concord, N. H.
JOHNSTON, F W	Springfield, Jackson & Pomeroy	Springfield, Ohio.
MILLER, W. H	Transfer & Stock Yard Company	Indianapolis, Ind.
PRICE, THOMAS	Cincinnati Southern	Cincinnati, Ohio.
PATTERSON, J. S	Indianapolis, Cincinnati & Lafayette	Cincinnati, Ohio.
ROBERTSON, THOS	Marietta, Pittsburgh & Cleveland	Marietta, Ohio.
SCHAFFER, AUGUST	Louisville, Cincinnati & Lexington	Louisville, Ky.
STEEL, W. J	Louisville & Nashville Gt. Southern	Nashville, Tenn.
SECHLER, E. K	Ohio & Mississippi	Pana, Ill.
THUMSER, JOHN	Ohio & Mississippi	Seymour, Ind.
WILSON, J. B	Ohio & Mississippi	Vincennes, Ind.

After recess.

THE PRESIDENT—It has been suggested that quite a number of members of the Association have come into the room since the calling of the roll; if so, will they please notify the Secretary.

The President then read his annual address.

PRESIDENT'S ADDRESS.

GENTLEMEN: Again I am permitted to greet you in assembling upon this our Twelfth Annual Meeting. At Richmond, last year, it was decided to meet here in the famous Queen City of the Great West, but more latterly known as the Paris of America, with its Davidson Fountain, its beautiful Eden Park; its famous Zoological Garden; its world renowned Academy of Music and Theodore Thomas; its inclined plane railways; and last, but by no means least, its Cincinnati Southern Railway.

We meet under the same pleasant general order of things which has prevailed throughout the country at each and every one of our meetings for the past eight years.

In one respect the outlook is more pleasant than heretofore, the continuance of prosperity is even more assured now than it was one year ago.

Resumption has proved so far a success, and if there has been no sudden increase of prosperity, there has been none of privation or poverty, but instead there has been, I may say, a gradual and steady increase or revival of all branches of business, which bids fair to be as permanent as it has been steady.

Our own society seems to share in the general prosperity, and if we have gained few members we have lost but few.

For a statement of the financial condition of the Association, I refer you to the very able and satisfactory report of your Secretary. For the first time in the history of the Association we find ourselves at the annual meeting free from debt, with a balance in the Treasury.

The interest in our meetings seems to me to be fully sustained.

We are reaping some benefit from our organization, I think, in the carrying out of its fundamental principle, viz: Railway Economy; but, although something has been done, yet there is still room for improvement; not, perhaps, in reducing wages, but in the improved methods of working and using our machinery.

My friends, economy must be the watchword for the next few years in operating the railroads of this country if we would have lasting prosperity.

Who can do more than the Master Mechanics toward educating the employees in their department to live cheaply, or at least within their earnings, which is the first lesson, and with many a hard one to learn.

We can also do much towards reducing the expenses of our departments by close and careful application. There is, however, a minimum or limit in that direction, beyond which it is not economy or safe to go.

We seem to be upon the verge of another railroad war upon rates, which would appear to be a suicidal policy, as the volume of busi-

ness is not increased to any appreciable extent by such reduction in rates, neither is the producer or consumer benefited thereby. I am of the opinion that if a fair, reasonable compensation could be fixed upon and adhered to, letting the business seek its own legitimate channel for transportation, the railroads as well as the country generally would be greatly benefited.

It has been my pleasure to be present at each of the gatherings since the first formation of the Association, in 1868, at which time, for some unexplained reason, I was selected to fill the office of First Vice-President, which office I held until the meeting in St. Louis, when, in the absence of your President, Mr. Britton, I performed his duties to the best of my ability.

It was your pleasure at that, as at the succeeding meeting, to do me the honor of electing me to the office of President, for which mark of confidence I am deeply grateful, but having held office for so long a time in this Association I think it is time for a change.

Your committees are entitled to commendation for the able and efficient manner in which their reports were presented at our last meeting.

I am informed by our Secretary that one of our members has gone before to that bourne from whence no traveler returns. I refer to J. B. Morse, late of the Eastern Division of the Wabash Railway. I trust suitable action may be taken by this Association in regard to the sad event.

Thanking you for your indulgence, I now invite your attention to the next business in order, which is the reading of the report of your Secretary.

The Secretary read his report as follows:

SECRETARY'S REPORT.

CINCINNATI, May 13, 1879.

To the American Railway Master Mechanics' Association:

GENTLEMEN—For the eighth time I have the pleasure of submitting to you my annual report.

At our last meeting we numbered 176 members; since that time twelve members have joined the Association, five have resigned, twenty have been dropped from the rolls, as required by Article IV

Section 4, of our Constitution, and one member is deceased. With these changes the Association numbers 161 members.

A proposition from Wilstach, Baldwin & Co., of this city, to print 1,200 copies, of 200 pages each, of the Proceedings of our last Annual Meeting for $557.75 was accepted; but as the report exceeded two hundred pages the price was increased over this sum to the amount $17.10, making the cost of printing our Eleventh Annual Report $574.85, and during the year we have distributed the following number: 270 copies to members, 360 to railroads and railroad officers, and 125 to locomotive works and other parties. There has also been sent out 105 copies of other reports, making the total number of all reports sent out 860, which number includes 72 copies sold by the Secretary and 35 copies sold by the Railroad Gazette. We have the following reports on hand: 577 copies of the First and Second, 42 of the Third, 281 of the Fifth, 24 of the Sixth, 91 of the Seventh, 368 of the Eighth, 316 of the Ninth, 302 of the Tenth, and 445 of the Eleventh.

The distribution of the reports to railroads was by instruction of the Supervisory Committee, six copies being sent to each of the roads contributing to our printing fund last year, with a request for a renewal of their subscription, which has been very generally responded to, and the following are the names of the roads and locomotive companies contributing, and the amount of their contributions to this fund:

NAMES OF CONTRIBUTORS TO THE PRINTING FUND.

ROAD.	AMOUNT.
Pittsburgh, Cincinnati & St. Louis—Pan-Handle Division, 1877-'78,	$24 00
" " " C., C. & I. C. " 1877-'78,	24 00
" " " Little Miami "	12 00
" " " 2d and 3d "	12 00
Pennsylvania Company—Pittsburgh, Ft. Wayne & Chicago..........	12 00
" " Jeffersonville, Madison & Indianapolis.....	12 00
Pennsylvania Central—G. Clinton Gardner........................	12 00
Cleveland & Pittsburgh..	12 00
Louisville, Cincinnati & Lexington................................	12 00
Arkansas Midland..	12 00
Chillan & Tallahuana, S. A..	12 00
Amount forward..	$156 00

ROAD.	AMOUNT.
Amount forward	$156 00
Cincinnati, Hamilton & Dayton	12 00
Connecticut River	12 00
Philadelphia, Wilmington & Baltimore	12 00
Mineral Range	10 00
Camden & Atlantic	12 00
Lehigh Valley	12 00
Illinois Central	12 00
Louisville & Nashville	10 00
Mobile & Ohio	12 00
St. Louis & Iron Mountain	12 00
Grand T. unk Railway of Canada	12 00
Chicago, St. Louis & New Orleans	12 00
Lake Shore & Michigan Southern	12 00
Northern Pacific	12 00
Missouri Pacific	12 00
Atchison & Nebraska	12 00
Cleveland, Columbus, Cincinnati & Indianapolis	12 00
Chesapeake & Ohio	12 00
Indianapolis, Bloomington & Western	12 00
Kansas Pacific	12 00
Toledo, Peoria & Warsaw	12 00
Canada Southern	12 00
Missouri, Ft. Scott & Gulf	12 00
Houston & Texas Central	12 00
Delaware & Hudson Canal Company	12 00
Atlantic & Great Western	12 00
Cleveland, Tuscarawas Valley & Wheeling	12 00
Northern	12 00
Concord	12 00
Western & Atlantic	12 00
New York, Lake Erie & Western	12 00
Delaware, Lackawanna & Western	12 00
Central Railroad of Iowa	12 00
Porter, Bell & Co. Locomotive Works	10 00
Pittsburgh Locomotive Works	15 00
Baldwin Locomotive Works	12 00
Brooks Locomotive Works	12 00
Schenectady Locomotive Works	12 00
Total amount Contributed	$609 00
Total amount received by Assessment	1,350 00
Total amount received by Initiation Fees	12 00
Amount forward	$1,971 00

Amount forward	$1,971 00
Total amount received by Sale of Reports	119 80
Amount received from Railroad Gazette for use of MS. for two years, 1877 and 1878	100 00
Donation from W. W. Evans	10 00
Making the total amount received	$2,200 80

For all of which I hold the Treasurer's receipts.

In June, after the adjournment of the Richmond Convention, the following letter from Wm. Toothe, of New York, was received by the Secretary:

"NEW YORK, June, 1878.

"*J. H. Setchel, Esq., Secretary M. M. Association:*

"We have remaining of a little fund raised at Richmond $59.05, which I am instructed to contribute to the exchequer of the M. M. Association. If this will be acceptable, please notify me and I will send check.

Yours very truly, WM. TOOTHE."

This was referred to President Chapman, who directed the Secretary to acknowledge the receipt of the letter, and say the $59.05 would be accepted and added to the Boston Fund.

A check for the amount was promptly forwarded, and is herewith included.

BOSTON FUND.

The original Boston Fund consisted of $3,000, presented to the Association by the citizens of Boston in May, 1872. This was placed at 6 per cent. interest until October 15, 1875, when it amounted to	$3,620 00
This, by instruction of the Association, was invested in three $1,000 bonds, paying therefor	3,615 00
Leaving unapplied	$5 00

The first interest collected on these $1,000 bonds was as follows:

January, 1876	$106 79
July, 1876	100 80
January, 1877	99 97
At date of January 6, 1877, the unapplied principal ($5) and the interest on these bonds amounted to	$312 56
Amount forward	$312 56

Amount forward	$312 56
When according to the instruction of the Association, as there was sufficient funds, two additional ten-forty bonds were purchased, paying therefor	231 50
Leaving uninvested	$81 06

Value of fund at date of January 6, 1877 ....$3,927 56

To this add the

Interest collected on three $1,000 bonds, July, 1877	$94 50	
" " " " " January, 1878	91 35	
" " " " " July, 1878	90 25	
" " " " " January, 1879	90 00—	366 10
Interest collected on two $100 bonds, March, 1877	10 40	
" " " " " " 1878	10 00	
" " " " " " 1879	10 00—	30 40
Amount of donation by Richmond Committee		59 05
Making the total value of fund		$4,383 11

Being the amount of the principal with interest accumulated up to this date.

At a called meeting of the Trustees of the Boston Fund, held May 12, 1879, at which Messrs. N. E. Chapman, of the Cleveland & Pittsburgh Railroad; R. Wells, of the Jeffersonville, Madison & Indianapolis Railroad; S. J. Hayes, of the Illinois Central Railroad, and J. H. Setchel, of the Little Miami Railroad, were present, a careful examination of the foregoing statement in regard to bonds and moneys belonging to the Boston Fund was made and found to be correct. The Trustees being advised that the interest on our bonds would cease in May and July, 1879, it was unanimously decided to exchange them for the 4 per cent. bonds. Accordingly thirty-seven hundred 4 per cent. interest bearing bonds were purchased, leaving a balance on hand unapplied at this date of $5.31.

I have given a full and complete history of the Boston Fund for the benefit of new members and those who may be particularly interested in looking after the financial condition of the Association.

The Secretary is in receipt of several mechanical and scientific periodicals from Europe and this country, which are the property of

the Association, and we are also the owners of a very fine dynamometer, presented by Thos. Prosser & Sons, of New York, which was duly stated in my report following its presentation.

All of which is respectfully submitted,

J. H. SETCHEL, *Secretary.*

Approved—N. E. Chapman, President; R. Wells, First Vice-President; S. J. Hayes, Treasurer.

Cincinnati, May 13, 1879.

THE SECRETARY—Mr. President, I desire to say that the Rogers Locomotive Works ordered this year, the same as last, fifty copies of the Reports, and paid fifty dollars for them, which is included under the head of Reports sold.

THE PRESIDENT—Gentlemen, you have heard the report of your Secretary, what action will you take upon it?

On motion, the report was received.

THE PRESIDENT—The next business in order is the report of your Treasurer. The report is in the hands of the Secretary, who will please read it.

The Treasurer's report was then read, as follows:

TREASURER'S REPORT.

S. J. HAYES, *Treasurer, in account with* MAY 13th, 1879.

THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

1878.		Dr.	1878.		Cr.
May 16	To Balance on hand..................	$789 25	May 16	Voucher No. 1, J. H. Setchel, Secretary...	$700 00
June 14	" Cash from Secretary	10 00	June 10	" " 2, Reporter's Bill..............	60 00
			May 22	" " 3, Cincinnati Safe Deposit C mpany.............. ..	15 00
1879.			May 20	" " 4, Wilstach, Baldwin & Co.	500 00
March 3	To Cash from Secretary..............	1,795 18	July 9	" " 5, " " "	200 00
April 11	" " " "	100 00			
April 28	" " " "	100 00	1879.		
March 24	" " " "	100 00			
May 12	" " " "	95 62	Jan'y 31	Voucher No. 6, Wilstach, Baldwin & Co.	234 75
			Jan'y 25	" " 7, " " "	685 43
			March 3	" " 8, Express Charges...........	1 25
			April 28	" " 9, Exchange on Draft........	25
			June 26	" " 10, Chase & Hall................	50
			May 17	" " 11, Britton, to Box Rent......	10 00
			May 1	" " 12, Wilstach, Baldwin & Co.	5 40
			May 1	Postage Bill to Secretary...........	41 75
				To Balance..	536 72
		$2,990 05			$2,990 05

Respectfully submitted,

S. J. HAYES, *Treasurer.*

THE PRESIDENT—Gentlemen, you have heard the report of your Treasurer, what action will you take upon it?

On motion of Mr. BLACK, the report was received.

THE PRESIDENT—It is necessary to appoint a committee to examine the accounts of the Secretary and Treasurer, and also to report upon the amount of assessment that may be necessary for the expenses of the coming year. Will some member please make a motion to that effect?

Mr. HAYES, Illinois Central Railroad—I move that a committee of three be appointed.

Motion carried.

THE PRESIDENT—I will appoint on that committee, Messrs. Richards, Boston & Providence Railroad; Johann, Wabash Railroad, and J. Davis Barnett, Grand Trunk Railway. It has also been our custom to appoint a Committee on Correspondence, as more or less is usually received, and we have always appointed a committee to select such as may be proper to come before the Association. Is it your pleasure that such a committee be appointed?

Mr. JOHANN, Wabash Railroad—I move a committee of three be appointed.

Carried.

THE PRESIDENT—I will appoint on that committee, Mr. Sedgley, Lake Shore & Michigan Southern Railroad; Mr. Fuller, Atlantic & Great Western Railroad, and Mr. Devine, of the Wilmington & Weldon Railroad. Any correspondence that may be received will be handed to them. According to a resolution, introduced two years ago, one hour of each day, from 12 to 1 o'clock, was set apart for discussion upon such questions or resolutions as any one might feel disposed to offer, to be brought up in the order presented, and I would say now that if any of the members have any resolutions or questions they wish to have discussed, they will please hand them to the Secretary so that they may be brought up at the proper time. The next business in order is the Report of the Committee upon Standard Car and Tender Axles. Said Committee consists of Mr. James Sedgley, Lake Shore & Michigan Southern Railroad; Mr. Cooper, of the Indianapolis, Bloomington & Western Railroad; Mr. Boon, of the Pittsburgh, Ft. Wayne & Chicago Railroad; Mr. Hudson, of the Rogers Locomotive Works, and Mr. Forney, of the Railroad Gazette. The report is in the hands of the Secretary, who will please read it.

Majority Report of Committee on Standard Car and Tender Axles.

To the American Railway Master Mechanics' Association:

GENTLEMEN—The Committee appointed at the last annual meeting, and which was instructed to confer with a similar committee

appointed by the Master Car Builders' Association, beg leave to report that some months ago they issued a circular asking for information in relation to this subject. The replies received have however been very few in number, although some of them have evidently been prepared with much care. In these Mr. G. A. Coolidge, Superintendent of Motive Power of the Fitchburg Railroad, says, that "the Master Car Builders' Standard Axle has been adopted on that line as the standard for general use," and that his "preference is for tender and car axles of the size or form known as the Master Car Builders' Standard."

Mr. John Hewitt, Superintendent of Motive Power and Machinery of the Missouri Pacific Railroad, writes, that the Standard Axles in use on that road have journals 3½ inches diameter by 6½ inches long, and "have given satisfactory results," and he, therefore, "would not advise the Company to change its standard. If, however," he says, "a new standard was necessary my experience would induce me to favor one with a journal *larger* than the Master Car Builders' Standard. As between the two, preference would be given to the latter."

Mr. Jacob Johann says, that he has adopted the Master Car Builders' Standard Axle for tender trucks. "At the present time all the engines on this division are equipped with this axle, and * * we are entirely convinced and satisfied by general observation that the use of the larger axle and journal possesses the following advantages over the smaller axles previously used: greater freedom from heating and consequent economy in the use of brass bearings, oil, and waste, and having but one axle for all, the quantity of wheels and axles carried in stock is materially reduced. * * * I am strongly in favor of the Master Mechanics' Association adopting the same standard, without change, as the standard tender axle. There is no reason for differing, and every reason both as to convenience and economy why the car and tender axles should be of uniform dimensions."

Mr. George Richards, Master Mechanic of the Boston & Providence Railroad, says, "that the Master Car Builders' Standard Axle has given the best results on his road, and that he would prefer it as a standard to any other size."

Mr. Herbert Wallis, the Mechanical Superintendent of the Grand

Trunk Railroad, says: "It would seem a pity to make any further alteration in the Master Car Builders' Standard Axle, to do which will certainly be to deter Companies in future from following their advice, which in many cases they have done for the sake of uniformity."

Mr. O. Chanute, Superintendent of Motive Power and Machinery of the New York, Lake Erie & Western Railroad, writes: "We have in service 475 locomotive engines. Of these 280 have journals 3⅜ by 6 inches, 171 have journals 3½ by 7 inches.

"We had in service September 30, 1878, 13,239 flat cars and 407 passenger cars. Of these twenty per cent. have journals 3¾ by 6 inches; sixty per cent. 3⅜ by 6 inches; twenty per cent. 3½ by 7 inches.

"The journals, 3½ by 7 inches, have given the best results. Experiments made with the dynamometer indicate that trains fitted up with them have less friction than other journals. The resistance of this journal being from 3.06 to 3.90 pounds per ton upon a level straight line at from six to ten miles per hour. We also find that we wear out a less number of brasses with this journal, 3½ by 7 inches, than with those of any other size.

"The axle which we prefer is that indicated in the print inclosed, which is 83¼ inches long over all; 82 inches between collars; journals 3½ by 7 inches; wheel seat 4⅝ inches diameter, with no abrupt curves. It weighs in the rough 326 to 332 pounds, and turned up weighs 314 pounds."

It will be noticed that Mr. Chanute does not report any axles on his road with the Master Car Builders' Standard Journal.

Mr. James M. Boon, Master Mechanic of the Fort Wayne Railroad, writes that he would prefer an axle 83 inches long over all; 81¾ inches between outside collars; 7 by 3¼ inch journal, and 4 inch wheel fit, weighing about 280 pounds finished. Cars weighing 20,000 pounds with these axles have been running for a number of years, and have given good results, carrying 30,000 pounds of freight, and axle-breaking has been of rare occurrence. The axle might be improved by increasing the journal to 3½ inches diameter so as to secure greater amount of wear.

Mr. Boon writes further: "I am not favorably impressed with the Master Car Builders' Standard, believing it to be heavier than neces-

sary. The heaviest cars I have knowledge of, carried on four pairs of wheels, weigh with wheels 20,000 pounds; less wheels and axles, 14,680 pounds; weight with load, 44,680 pounds. This would give on each $3\frac{1}{4}$ by 7 inch journal 5,585 pounds. The breaking weight of this journal, with weight in center of length, is 54,000 pounds; weight on outside end of journals 27,000 pounds. Supposing the whole weight to be thrown on outside end of journal, their remains a margin of 21,415 pounds between the load and breaking weight. Same with the four-inch wheel fit, weight being about the same as on journal. The breaking weight inside of wheel fit will be about the same, leaving same margin of 21,415 pounds between load and breaking weight. The breaking weight given here is the theoretic weight; I believe in practice it will be found too low. This strength appears to me to be ample and leaves margin for yet further increase of load. But it will be urged that these axles have broken; certainly they have, and I have knowledge of several axles breaking in six-wheel trucks which had $3\frac{3}{4}$ inches diameter by 8 inches long journal and $5\frac{1}{8}$ inch wheel seat. Taking the average, the breaking of these made a very bad record. There were but thirty of them on the road; two breaking out of the thirty, while of some 1,500 standard wrought iron axles, $3\frac{1}{4}$ by 7 inch journals in six-wheel trucks, there was not one broken during the whole winter. Again, the standard axle of this road weighs 280 pounds finished, the Car Masters' 350, therefore the latter axles in our car would weigh 300 pounds more than the former. The Car Masters' Oil Boxes weigh for one car 644 pounds, whereas those of our standard weigh only 440 pounds, or a difference of 204 pounds in favor of the latter. The Car Masters' brass weighs 10 pounds, our standard 9 pounds, or eight pounds per car less than the Car Masters', or a total excess of 502 pounds per car. The cash value of this excess of weight is \$11.39. This does not include the cost of changing the arch bars, bolts, etc., which cost should be added. This excess of weight and of value for one car is a small item; but when it comes to be charged to the entire equipment of a road it becomes a very large sum, which few if any roads would be able to stand."

It should be noted that Mr. Boon is in error about the weight of the Master Car Builders' Standard Axle. As made for the New York Central Railroad it weighs finished only 335 pounds instead of

350, as given by Mr. Boon. The difference in weight for one car between his axles and the latter would be 220 pounds, not 300.

Mr. S. J. Hayes, of the Illinois Central Railroad, writes as follows:

ILLINOIS CENTRAL RAILROAD COMPANY,
[Office of Superintendent of Machinery.]

CHICAGO, March 27, 1879.

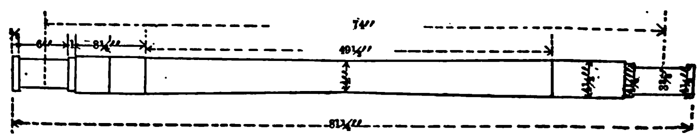
JAMES SEDGLEY, ESQ., Gen'l M. M., L. S. & M. S. R. R.,
CLEVELAND, OHIO:

DEAR SIR—Replying to the circular of your Committee regarding the best form and proportion for a Standard Car and Tender Axle, I submit the following as the result of my experience:

1st. 4,894 freight; 171 passenger; 5,065 total cars.

2d. 212 engines.

3d. We use but one form of axle for tenders, passenger, and freight cars, of the dimensions shown in the following sketch:



Gauge of Track 4 fee 8½ inches.

4th. This is the only axle we have used; it has been our standard for twenty-five years, and has given the best results. I have never known one to break with fair usage, and we have axles now in service under freight cars that have been in use for twenty years and are still in good condition. Under tenders and passenger cars their service is limited to two and one-half years; they are then transferred to freight cars and run until the diameter of journal is reduced to three inches, when they are removed from service. When made of a good quality of iron, and for a maximum car load of twelve tons, I consider it the best form of axle I have seen.

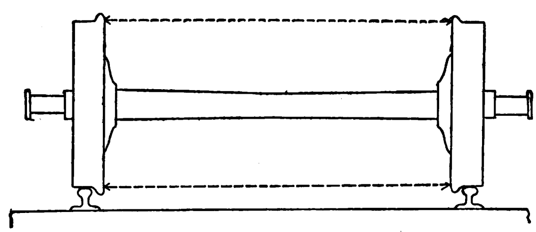
5th. Were the maximum car load limited to twelve tons I should not, considering the experience I have had with our present axle, be in favor of making any change in its dimensions; but the tendency being to heavier loads, will, when the practice becomes generally adopted, necessitate larger and stronger axles. For this reason I am

in favor of a standard axle for all roads which will be of sufficient strength to meet all the requirements of traffic. For this standard I would recommend the following dimensions:

Length over all, 82¼ inches; journals, 3½ by 7 inches; diameter at wheel seat, 4⅞ inches; distance from center to center of journals, 74 inches. I am not in favor of increasing the distance from center to center of journals, believing it to be much safer and less destructive to the axle to have the bearings kept close to the wheel seat. My reasons for this are that an axle with outside bearings is, when loaded, subject to a strain which springs the axle in a degree proportionate to the load and distance of the bearing from the wheel seat; the ratio of this deflection is not exactly known, but the following experiments, made in the summer of 1877, will serve to show to what extent an axle is sprung when a car is heavily loaded.

A new axle, with new wheels faced on inside of the flanges, was placed under an eight-wheeled coal car. The measurements given were taken with a steel gauge, and represent the difference between the flanges at the top of wheels and near the rails:

1. With weight of truck only.. $\frac{1}{64}$ inch.
2. With weight of car body only.. $\frac{3}{64}$ "
3. With load of 10,000 pounds all in one end over the wheels measured.. $\frac{6}{64}$ "
4. With load of 20,000 pounds evenly distributed on car.......... $\frac{7}{64}$ "
5. With load of 25,750 pounds evenly distributed on car.......... $\frac{8}{64}$ "
6. With load of 36,000 pounds evenly distributed on car......... $\frac{9}{64}$ "



These results, I think, show the necessity for keeping the bearings close to the wheels.

The journals of the axle we are using can be lengthened to seven inches without changing the distance between their centers. On most of the foreign cars I have examined the journal boxes can be

placed much closer to the wheels, than seems to be the general practice, and ample allowance made for end play.

6th. I object to lengthening an axle any more than is absolutely necessary. With 4 feet $8\frac{1}{2}$ inch gauge of track a car axle $82\frac{1}{4}$ inches in length is as long as is needed. Journals $3\frac{1}{2}$ by 7 inches are sufficiently large, in my opinion, to safely carry a maximum car load of fifteen tons.

Yours truly,

S. J. HAYES, Supt. Machinery.

During the past year the Chairman of this Committee had a series of experiments made on the different divisions of the Lake Shore Railroad, to determine the relative wear of brasses on axles with $3\frac{1}{2}$ by 7 inch and $3\frac{3}{4}$ by 7 inch journals. The records of these experiments are submitted herewith, and are recommended to be printed with this report. The result may be summarised as follows: On the Buffalo Division, two axles with $3\frac{1}{2}$ by 6 inch and two with $3\frac{3}{4}$ by 7 inch journals were put under two tenders. The $3\frac{3}{4}$ inch journals run the front and back axles of the two trucks, and the small journals were in the two middle axles. The average loss of weight of brass in the large journals in running 11,760 miles was $14\frac{3}{4}$ ounces, and the average loss of the brass in the small journals was $6\frac{5}{8}$ ounces. On the other tender in which the journals were arranged in the same way, the large journals each lost 1 pound $7\frac{1}{2}$ ounces, and the small ones lost $12\frac{1}{8}$ ounces. The wear of journals was almost exactly the same in each case.

On the Western Division of that road similar experiments showed an average loss in weight of two, $3\frac{3}{4}$ by $7\frac{1}{4}$ inch-journal bearings, of 2 pounds $8\frac{1}{2}$ ounces, and an average loss of four, $3\frac{1}{2}$ by $7\frac{1}{4}$ inch-bearings, of 1 pound $5\frac{1}{8}$ ounces. On the Cleveland Division, the average loss of weight of the $3\frac{3}{4}$ inch brasses was $3\frac{7}{8}$ ounces, and the small one $4\frac{1}{2}$ ounces, in running 8,225 miles.

Of the advantages which would result from the adoption of a common standard for car and tender axles, the Committee do not think it is necessary to speak, as they are sufficiently obvious; nor is it, perhaps, so important that the best possible standard should be adopted, as that the railroad companies should be led to *agree* on some one standard. It was for the purpose of bringing about

agreement that this Committee was instructed "to confer with the Master Car Builders or any other parties."

A meeting was therefore called and held in New York, on April 17th. There was present at that meeting Mr. F. D. Adams the Chairman, and Mr. S. A. Davis, a member of the Car Builders' Committee; Mr. McCallum the Secretary of the Eastern Railroad Association; Mr. Cloud, of the Pennsylvania Railroad; the Chairman and Mr. Hudson of your Committee, and Mr. Forney, a member of both Committees.

After full discussion it was found that all present were agreed in recommending the present longitudinal dimensions of the Master Car Builders' Standard Axle. The members of the Master Car Builders' Committee who were present at the meeting were all in favor of recommending the other dimensions of that standard. Part of your Committee, however, were of the opinion that a smaller axle would be preferable, and were therefore in favor of recommending a standard of the same length as the Master Car Builders', but $\frac{1}{4}$ inch smaller in diameter all through.

As entire agreement seemed impossible, the members of the Master Car Builders' Commitee who were present adopted the following resolution:

"*Resolved*, That the members of the Committee on Standard Axles of the Master Car Builders' Association at the meeting held April 17th, in New York, recommend *preferably* the adoption of the Master Car Builders' Standard Axle; but in case the Master Mechanics' Association will not agree to this size, the Committtee will concur in recommending the adoption of a standard of which the longitudinal dimensions are the same as the Master Car Builders' Standard and the diameter $\frac{1}{8}$ inch less."

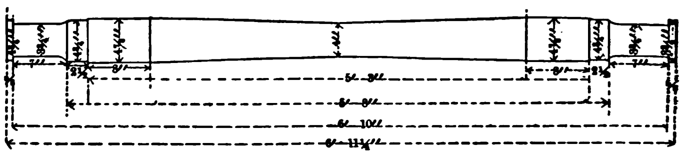
Your Committee, therefore, propose the adoption of the following resolution by this Association:

"*Resolved, That the American Railway Master Mechanics' Association recommend the adoption, by railroad companies, of the longitudinal dimensions of what is known as the Master Car Builders' Standard Axle, as a common standard for axles for all new or reconstructed tenders and cars.*"

It is for this Association to determine whether it would be wisest to recommend as a standard for axles the same diameters as those which the Master Car Builders' Association has adopted, or whether the diameters should be *smaller* or *larger*. If it is determined to

concur with the Master Car Builders' present standard, it can be done by the adoption of the above resolution, after first striking out the word "*longitudinal.*"

JAMES SEDGELY,
H. L. COOPER,
M. N. FORNEY,
W. S. HUDSON,
JAMES BOON,
Committee.



THE SECRETARY—Mr. President, there is also a minority report. Shall it be read now?

THE PRESIDENT—Is that minority report from the Committee upon Standard Axles.

THE SECRETARY—Yes, sir; and I think it should be read now as it is a continuation of the report of the same Committee.

Supplement to Report of Committee on Standard Car and Tender Axles.

To the American Railway Master Mechanics' Association:

GENTLEMEN—In addition to the report of the Committee on Standard Axles I desire to submit the following:

It may be safely assumed that twenty years ago that an axle with journals $3\frac{1}{4}$ inches in diameter and 6 inches long was regarded as the best, or very good proportions, for eight-wheeled cars weighing about 17,000 pounds and intended to carry 20,000 pounds of load. The breaking weight for this or any other journal may be determined by the following rule: *Multiply* 3.1416 *by* 50,000, *and the product by the cube of its radius and then divide by twice its length.* Calculated by this rule the weight required to break off a journal of the above size would be 56,127 pounds. The total weight of such a loaded car would be 37,500 pounds, and the weight of the wheels and axles would be 5,000 pounds, so that the weight on each journal would be a little over 4,000 pounds, and the breaking strength of this journal would be about *fourteen* times that of its load.

This, as I have stated, was considered good practice twenty years

ago. The bearing surface on such a journal measured in the diameter would be $3\frac{1}{4} \times 6 = 19\frac{1}{2}$ square inches, so that the journal carried a little over 200 pounds per square inch.

At present the practice is to build cars which weigh 20,000 pounds and carry 30,000 pounds of load; deducting 5,500 for the weight of the wheels and axles and we would have a total weight of 44,500 pounds, or a little over 5,560 pounds on each journal, If then we have the same margin of strength in the axles for the cars of the present day that we had twenty years ago, the journals should have a breaking strength of $5,560 \times 14 = 77,800$ pounds. A $3\frac{3}{4}$ by 7 inch journal would require 74,014 pounds to break it, so that it has somewhat *less* margin of safety than the $3\frac{1}{4}$ by 6 inch journals had twenty years ago.

Let us see about the bearing surface in the old cars: as was shown there was a square inch of surface to each 200 pounds of load in the old cars, so that for a load of 5,560 pounds we ought to have 27 square inches of surface. A $3\frac{3}{4}$ by 7 inch journal has only $26\frac{1}{4}$ square inches of effective bearing surface, I am, therefore, of the opinion that for the loads which are now carried that the Master Car Builders' Standard is rather too small than too large; and, consequently, it would be a great mistake to diminish it in size.

In 1873, when the present standard was adopted by the Master Car Builders' Association, I was asked to state what size of journal I thought should be adopted for a standard axle. I was then alone in recommending a journal 4 by 8 inches. I still believe that would be in every way the best size; but, be that as it may, it is to be hoped that this Association will not go backwards and recommend a standard axle *smaller* than the one which has now come into considerable use. If any change is made it would seem desirable to make it in the other direction, and increase, rather than diminish, the size of the Car Builders' Standard.

M. N. FORNEY.

I concur in the above. W. S. HUDSON.

THE PRESIDENT—Gentlemen, you have heard the report of your Committee upon Standard Car and Tender Axles, what is your pleasure in regard to it?

Mr. JOHANN, Wabash Railroad—I move that it be received, with the understanding that receiving the report does not dispose of the question.

THE PRESIDENT—No, sir, it does not.

Motion carried.

THE PRESIDENT—Gentlemen, the question is now open for discussion.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, as you all very well know a large number of the members hold extreme views in regard to the best axles to be adopted by our Association, perhaps it would be well for me to state the reasons for the conclusions we have formed. As we took the usual form of issuing circulars, and as the subject is so simple, it would seem a very easy matter for the members to state their preference, but I am sorry to say we received only seven replies to our circular. We also had a meeting in New York with the Committee of the Master Car Builders' Association, where we discussed the matter extensively. It was evident from the information we then had that we could not agree upon the Master Car Builders' Standard. We felt safe to recommend the longitudinal dimensions, but we could not decide upon the diameter of the axle. Some of the leading roads have a great many cars with 3½ inch journals, and it seemed impossible for us to agree to make the journal 3¾ inches, so we left the matter in that way and have submitted our report accordingly; and, as it is a matter in which we are all interested, I hope the subject will be thoroughly discussed and voted upon to determine whether we will adopt the Car Builders' Standard or some other diameter for our axles. I would say on the part of the Master Car Builders' Committee, that while at their Convention they recommended 3¾ inches as a standard journal and 3⅞ inches for the wheel fit, they agreed in case the Master Mechanics' Association would not adopt it to recommend a modification of their standard, making it 3⅝ inches for journal and 4¾ inch wheel seat. It is now for this Convention to determine whether they will adopt their standard, and I am very anxious to hear from the members on this point. In regard to the supplementary report of the Committee, which I hope will be received and printed with the proceedings of this meeting, I would say those men, perhaps, held extreme views in regard to the axle. Apparently the axle 7 by 3¾ inches is not any stronger to-day than 3¼ by 6 inches was twenty years ago. It does not give the bearing surface, if we accept 30,000 pounds as a load for a car and take into consideration the character of the road.

Mr. JOHANN, Wabash Railroad—Mr. President, I conclude that receiving the report and supplement simply brings the matter before the Association. If this is correct, it is no more than right that they should go into print. I am very well pleased, indeed, that these reports on the axle question read as they do. My opinion in regard to a standard axle is, that although a standard may not be the best, it is decidedly preferable to having no standard at all; and unless we enter into this matter with a spirit of compromise I do not see how we are ever to arrive at any definite conclusion. I think we have had this question under consideration long enough, and I would like to see the members enter into a hearty discussion

of it and then come to some definite decision. I have already given my written opinion on the subject to the Committee in charge of this question. A few years ago I had a great variety of dimensions in tender axles, which were continually causing me a great deal of trouble. I finally laid the matter before our officers, and they consented to my adopting the Master Car Builders' Standard Axle for my tenders. I have eighty-two engines under my charge, and when I began to adopt the standard I anticipated much difficulty and expense in making the proposed change, but was agreeably surprised at the comparative ease and economy with which the change was brought about. At the same time I adopted the standard axle I designed and adopted a standard truck complete, with thirty-three inch wheels, and was very much surprised at the rapidity with which our tenders became uniform, and what an advantage such uniformity possessed over the old system. With the great variety of tender trucks and axles formerly used, a large amount of round house and night and Sunday work was required, which under the present system I am enabled to entirely dispense with as I now keep two spare trucks on hand, and when a tender requires truck repairs I take them out and put in my spare trucks, and repair those that are broken at my leisure, without working my men overtime, nights or Sundays, which I claim to be a great saving. This radical change can not be brought about at once, but must come gradually. We all know, however, that in the course of a year there is a certain proportion of our machinery that becomes so worn down that it is necessary to throw it out of service, and if any member will begin to replace his worn-out or broken tender axles with the standard, he will be astonished to find with what facility he is able to introduce it without discarding any good material, and before he is aware of it he will have the standard extensively in use. Our road has adopted the the Master Car Builders' Standard simply for the sake of having a uniform standard. I do not exactly agree with the Committee report that recommend retaining the Master Car Builders' length of journal, but advocate a smaller diameter as to the dimensions for a standard; and although the dimensions of the standard axle now before the Convention may not be the best, yet it is decidedly better to accept them than remain without a standard. I simply desire uniformity in our trucks by having a uniform axle, which will prevent the necessity of keeping a large number of axles in stock. I think that many of us will live to see the time when all the roads will have a uniform standard, and that it is our duty as an Association to extend our influence towards bringing about such a change. In my opinion, as the Master Car Builders' Association has adopted such a standard, and as they are willing to compromise with us upon a size, it is no more than right and proper that we should concur with them, and that every member begin at once to work it into use. If this is done, in three or four years you will be astonished to see how universally the standard axle has spread itself among the various roads. This is not a question of the one-sixteenth

or even the one-eighth part of an inch, but the question is on a standard for all railroads in America, so that if I get a car from the New York Central or the Union Pacific that requires a new axle or brass, I will not have to wait and send for one before I can forward the car to its destination, for with a standard truck I would be enabled to slip the axle or brass out and put in others without detaining the car more than an hour or so, where otherwise it would be detained for days.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I think it is very important that a standard axle should be adopted. As Mr. Johann says, you can not effect it all at once, but the time seems now to have come when some action should be taken and a standard axle adopted. The question with me is, are we not increasing the weight of our rolling stock beyond the increase of the carrying capacity? Now I would like to ask any member present if he has ever known of a 3¼ inch journal, without defect, to break by fair usage. I should be very glad to see a standard axle adopted; but unless we can increase our carrying capacity I would be in favor of a smaller axle. I have never known one of our axles to break under fair usage, although our present size is smaller than the standard. Will we gain any good results in the end by having a standard axle beside unifomity? If we can not run our machinery with the same economy now that we could twenty years ago with the same capacity, we are not making much headway. We all know that the weight between the spring and the rail is very great, and I would like to know if we are not adding more superfluous weight by adopting this axle unless we are getting a better carrying capacity.

Mr. WHITE, Evansville & Crawfordsville Railroad—Mr. President, in regard to breaking 3¼ inch journals I do not think we have ever broken any on our road, but it seems to me too small a size to commence with. It is now about six years since we put 3½ inch journals under our coaches. I enlarged our axles and journals with very good results. We have never had any trouble with hot journals since running the larger journals, and I find brasses wear a great deal longer now than before. My foreman handed me a statement as I was coming away, which he had been keeping of the mileage of brasses. I find one that has run 18,000 miles and is not worn very much either. Our axles are a little lighter than the standard; still I am not opposed to the standard. I think it is a move in the right direction. We should get our bearings as near the wheel as possible and give room for the boxes. Of course the nearer we have it to the wheel the less diameter we will require in the center to keep the axle from springing.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I do not wish the members to understand that I favor a 3¼ inch axle, I only speak of it as a size that has been in use for a long time. I do not object to a 7 inch journal. The question is: shall it be over 3½ inches in diameter, or shall it be the same as the old axle in use twenty years ago?

Mr. WARREN, St. Louis, Alton & Terre Haute Railroad—Mr. President,

I started out with 3 by $5\frac{1}{2}$ inches, and from that I went to $3\frac{1}{8}$ by $5\frac{1}{2}$ inches, and from that to $3\frac{1}{4}$ by 6 inches; but for the past seven years I have adopted $3\frac{1}{2}$ by 7 inches with $4\frac{1}{2}$ inch wheel seat, and we can carry from twelve to seventeen tons in our cars without any difficulty. I should be in favor of that size as it does not necessitate a very large expense in changing the truck.

Mr. ORTTON, Canada Southern Railroad—Mr. President, I am in favor of the Master Car Builders' Standard 7 by $3\frac{3}{4}$ inches. I was present at their meeting when this question came up. They were willing to concede $\frac{1}{8}$ of an inch, in order that uniformity might be obtained between the two Associations. I think they have shown a disposition to harmonize the opinions of each, and I am not in favor of throwing obstacles in the way of adopting a standard axle. I think it is a matter of courtesy that this Association should join in recommending their sizes. You deem the longitudinal dimensions correct, and the only difference is in the wheel seat. If the $\frac{1}{4}$ inch would be an advantage to us they are even willing to concede to that. Where you have a small journal your oils clog up and you have hot boxes. Mr. Simonds has stated that if the axle gets fair usage it will not break. I have seen a number of axles break at the journal without getting hot, and for this reason I would prefer even a larger size than the Car Builders' Standard; but I am willing to compromise, and if this Association fails to take action in regard to this matter it will be for the want of a little courtesy and nothing else. As for myself I shall vote to adopt the Master Car Builders' Standard.

Mr. BLACK, Dayton & Michigan Railroad—I move that the Master Car Builders' Standard Axle be adopted by this Association.

Mr. SELBY, St. Louis, Kansas City & Northern Railroad—Some years ago we had axles on our road $3\frac{3}{8}$ by 6 inches, and we found after three or four years wear that a great many of them broke, many of which were made by first-class manufacturers, and some of them were not over four years old. We then adopted an axle 4 by 7 inches, and we have had these in service for eight years and have never had any trouble with them, and when we wanted some additional cars in our equipment our people thought it best to get something by which we could carry from twelve to sixteen tons in a car, and at the same time secure uniformity, and eventually decided upon the standard axle as the one they wanted.

Mr. JOHANN, Wabash Railroad—Mr. President, I hope my friend, Mr. Black, will not press his motion to adopt and so curtail the discussion, for the reason that this question is the most important one we have before us at this session, and I desire sufficient discussion to enable us to arrive at some definite conclusion. I would therefore suggest that Mr. Black withdraw his motion, and that every member present be requested to express his views upon this subject. If he still insists on his motion, I shall move to amend it, making this subject a special order for 10 o'clock to-morrow morning.

THE PRESIDENT—It will be necessary for Mr. Black to withdraw, or else we must vote on his motion.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, I will withdraw my motion, but we have spent too much time already to-day on this axle question.

THE PRESIDENT—Will your second also withdraw?

Mr. BLACK, Dayton & Michigan Railroad—Yes, sir.

Mr. JOHANN, Wabash Railroad—Mr. President, as Mr. Black has withdrawn his motion, I would say that the four trunk lines, as we call them, or rather three of them—the New York Central, Erie and the Pennsylvania Central—may possibly be prevailed upon to adopt the length of the Master Car Builders' Standard. If that can be accomplished I will vote for that standard for the sake of getting the axle question into some shape. If such lines as the above will consent to adopt the standard there will be no trouble about bringing it into general use, because it is an absolute fact that these lines are the most important in America, and probably control the largest number of cars of any other three companies. I have not the least doubt but that the Master Car Builders would be willing to recede from 3¾ inches so as to make a compromise with this Association, and, therefore, I hope all the members will take it under consideration until to-morrow morning.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, I would like to know if Mr. Johann is going back on the standard axle he has been advocating in this Convention for several years.

Mr. JOHANN, Wabash Railroad—Mr. President, I go back on nothing. I would prefer a 4 inch journal for a standard, as that would not necessitate any change in my journal boxes. I can use 3¾ inches and wear it down to 3½ inches, and then I will be standard; but I hope the question will be postponed until to-morrow morning, so as to give all the members plenty of time to take the matter under consideration, and I think, as I said before, that if the trunk lines can be prevailed upon to adopt this axle it will not be very long before it will have come into general use.

Mr. WIGGINS, Houston, East & West Texas Railroad—Mr. President, I am a member of the Master Car Builders' Association and was at the meeting when the standard axle was adopted, and we had a very warm discussion on it then, and we have had the subject before this Association for several years, and it seems to me we are spending time for nothing discussing an eighth or a sixteenth part of an inch while there is more important business to attend to. We should decide this matter at once. I think the Car Builders' Standard comes nearer to what is in general use than anything we have and, therefore, I am very anxious that we should come to the point and settle this question forever for the members.

Mr. SETCHEL, Little Miami Railroad—Mr President, I do not think we have any business of more importance than the one we now have under discussion.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I think, from what has been said about this matter, we had better adopt the Master Car Builders' Standard as they now have it. The principal objection seems to be in the size of the journal, and it seems to me that this ¼ of an inch does not amount to any thing; 7 inches by 3¾ inches in length will not be too heavy. Some roads wear their journals ¼ of an inch before rejecting them, and if you adopt 3¾ inches after it wears down to 3½ inches, those desiring that size will still have it, and as some roads wear their journals much smaller we will have almost any size you want.

Mr. WARREN, St. Louis, Alton & Terre Haute Railroad—Mr. President, there is no objection, as Mr. Sprague says, of adding ¼ of an inch to the journal. I think if we adopt the Car Builders' Standard in length, they will in all probability make it 3½ inches, although I think 3¾ inches is not too large. It can be easily worked in boxes for 3½ inch journals, and you will still have sufficient space for the collar of the axle, and it is just the same with the tenders, 3½ inches will work in between them. If the small journals get fair usage there will be no trouble, but the difficulty is they don't.

Mr. SIMONDS, Cincinnati & St. Louis Railroad—Mr. President, in my remarks about the fair usage of journals, what I meant by fair usage was proper care in the hauling of ordinary traffic. What I call unfair usage is allowing them to get off the track and run with hot boxes. On all roads more or less of the rolling stock has to be renewed every year, and if the Master Car Builders' Standard is adopted I do not see why it can not be used to replace as well as any other.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, I am glad to hear this discussion in regard to the axle, but I would have the gentlemen bear in mind that the matter of which we have talked about more or less at this session is not the size of the axle each one would prefer, it is the amount of difference requisite in carrying loads. Some gentleman remarked that it is not known what the trunk lines will adopt. Now it is well known that the New York Central has adopted the Master Car Builders' Standard, also the Boston & Albany. The Pennsylvania Central has intimated that they would come to a 3½ by 7 inch journal with 4½ inch wheel-seat, and I think the Erie Railroad will adopt the same. I hope the gentlemen will weigh this matter, and if we adopt a standard axle we will select a standard that the leading roads will adopt, and that it will be adapted to the convenience of all roads where there is a large interchange of cars throughout. Although I have nothing to do with the cars on our line I am aware that there is a great inconvenience in the multiplicity of axles, which causes considerable trouble and expense to keep different sizes and lengths on hand; therefore, I am willing to make concession for the axle that the principal roads will adopt, and judging from the replies received by the Committee there is little doubt about the length of the axle. There is no doubt the adoption of it would be important to new roads in ordering rolling stock to

know what kind of axles would be best adapted to an interchange of cars. It is also of importance to remember that the journal should be close to the hub of the wheel. While we may not do a great deal in bringing a standard into general use, still I have given considerable thought and attention to it, and the gentlemen who composed the Committee when we came together came with the determination to settle this question if possible. I am glad to say that while the Master Car Builders' Committee were men who held extreme views in regard to large axles, they were willing to make concession if we could agree with them upon something else. I hope all the members present will see this matter in the same light as the Committee, and lay aside personal preference, to a certain extent, for the purpose of getting an axle that will be adopted by a large class of the roads or a majority of the roads in the country.

Mr. King, Western Railroad of Alabama—Mr. President, there is evidently a tendency among the Master Mechanics to increase the size of the journal. Two years ago our journals were 3½ by 5½ inches, now the last new cars we got were the Master Car Builders' Standard. I am not prepared to say whether our road will adopt their axle or not, but all that we have received lately have been of this pattern.

Mr. Ortton, Canada Southern—Mr. President, we can not expect every line and every road to adopt the standard axle all at once; that is impossible, and no road can afford to do it. I am in favor of anything that will make concession; but I do not think ¼ of an inch in diameter will make any great differencce with the members of this Association. We can not do anything in regard to it but to express our opinion. We can not say to our superior officers we are going to adopt this thing. To adopt it here is simply to express our opinion in favor of it.

The President—Gentlemen, the hour of 12 o'clock has arrived, which, according to a resolution adopted by this Association, is the time for the introduction of any subjeets that may have been presented for discussion.

Mr. Johann, Wabash Railroad—Mr. President, before we proceed, I move that the discussion on Standard Axles be postponed and made the special order for 10 o'clock to-morrow morning.

No second.

The President—It has been our custom about this hour in the day to take a recess of ten minutes, and any questions that may be desired can be handed in during that time.

On motion, the Convention took a recess of ten minutes.

AFTER RECESS.

The President—If there is no objection the first business in order will be the report of your Finance Committee on Assessment. The Secretary will please read the report.

The Secretary then read the report.

Report of the Finance Committee.

To the American Railway Master Mechanics' Association:

Gentlemen—Your Committee appointed to examine the accounts of the Secretary and Treasurer, would report that they have attended to that duty and find their reports correct, and we would recommend that an assessment of $5 upon each member be made to defray the expenses of the coming year.

Very respectfully,

GEO. RICHARDS,
JACOB JOHANN,
J. DAVIS BARNETT, } *Committee.*

On motion, the report was adopted.

The President—Mr. Secretary, has there been any questions handed in for discussion?

The Secretary—No, sir.

The President—Then the next business in order is the continuation of the discussion upon Standard Car and Tender Axles.

Mr. Hewitt, Toledo, Peoria & Warsaw Railroad—Mr. President, I, for one, would like to hear the experience of every Master Mechanic present in regard to what he thinks is the best standard axle. When I assumed control of the motive power of the road which I represent, I found a variety of axles, which I think would astonish any Master Car Builder. My foreman and I came to the conclusion that a standard should be one that could be used for cars and tenders, which would not only be a benefit to our individual roads but it should be arranged so as to make it a mechanical improvement. In looking around we found nothing better than the Master Car Builders' Standard, which we adopted, and to-day I have nearly all our locomotives and tenders equipped with this axle. Previous to the adoption of this standard we had axles from 3¼ by 5 to 3½ by 5¾ inches in length. Some of them were replaced under what is known as the iron truck, or an old truck, that used to be built by the Rogers Locomotive Works, which, of course, placed the axle more rigid than under the present plan. We had two or three accidents on the road with these trucks, and with small axles, which laid out our passenger trains and caused considerable delay, besides

destruction to property, and under these circumstances we undertook to select something that would be strong enough to sustain the loads we were carrying. We are all aware that the business on every road is running lower every day by competition, and that it will be required of us to do more work with engines and to increase the capacity of our cars so as to carry heavier loads. When we do this we will have moved in the right direction and save expense to the companies we represent.

Mr. FLYNN, Western & Atlantic Railroad—Mr. President, there is another thing to be considered in regard to this axle, that is the gauge of the different roads. Now in the South our gauge is 5 feet while the gauge East is 4 feet 8½ inches. I remember at one time, when I had charge of a road, I made an examination of the different kinds of axles and found that I had nine different sizes in use. I think it becomes essentially necessary to adopt a standard axle, and if we do adopt one we should adopt that which will be most easily adapted to the different kinds of trucks in use. Since 1858 I have never had an axle break, and since that time our axles have ranged from 3¼ to 3¾ inches by 6 inches in length. I would have no material objection to the adoption of a standard axle, but I doubt very much whether one could be very successfully adopted for all gauges, and it strikes me very forcibly that if the Association adopts a standard it must adopt one that will suit either 5 feet or 4 feet 8½ inch gauge. While I have no great objections to the Master Car Builders' Axle, I have some little objection to the expense of heavier axles which is something we should all take into consideration. We should establish an economical precedent in adopting anything new. In conclusion, I would say that I have no objection to a standard if one can be adopted to suit the majority of the roads of the United States.

Mr. JOHANN, Wabash Railroad—Mr. President, I believe there is a gauge different from what we call the standard gauge; but to come to the point in regard to Mr. Flynn's remarks, I simply wish to say that I think we will all probably live to see the time, and before a great while, when Mr. Flynn's road will adopt the 4 feet 8½ inch gauge. Of course it is impossible to bring this standard axle into use on roads where the gauge is 5 feet unless the gauge be changed to the standard gauge, which is 4 feet 8½ inches, and I hope the 5 feet-gauge men will take a stand and advocate the adoption of the "*American Standard Axle*," for the time will soon come when the circumstances of traffic will render it necessary to reduce the 5 feet gauge to 4 feet 8½ inches.

Mr. SEDGLEY, Lake Shore & Michigan Southern—Mr. President, I wish to make a statement for the Committee in regard to our report for a standard axle. We should have said it was a 4 feet 8½ inch gauge. In the interchange of wheels in cars from 4 feet 8½ inch to 5 feet gauge the journal does not fit in the boxes, but you can use the same axle by varying the wheel seat.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I think the same axle can be used except as to the distance between the wheel seats.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, nearly twenty-six years ago, when I took charge of the machinery of the road which I now represent, the standard axle used then was 6 feet 6 inches in length, with a journal 5¾ by 3¼ inches. We had these axles in use until about thirteen years ago, when we experienced some trouble with journals and brasses heating under our heavy cars, and we then adopted a standard 6 feet 9 inches in length with journals 7 inches long by 3½ in diameter, which we have continued to use up to the present time. But in the meantime we have increased the journal of new axles ⅛ of an inch, and we have to-day much better results from the use of large journals than we had with smaller ones. I have always been in favor of large journals, which the proceedings of this Association will show; and I think the objections that I have heretofore made to the Master Car Builders' Standard was not against the size, but in the length of the journal and the total length of the axle, as it brought the center of the journal farther out over the rail than is necessary. If the journal could be made 7½ inches outside the rail, or if that could be shorter; for instance, if you shorten one inch on each end you will have the center of the journal some ten per cent. less distant from the center of the bearing on the rail, and there will be less strain upon the axle. Now, as to the adoption of some particular size, I do not think it is of much matter, but there is a little objection to the adoption of the Car Builders' Axle because some fear it is too long; some say that 6 feet 9 inches and others that 6 feet 9½ inches is long enough where the journal is 7 inches. We experience no difficulty in getting our boxes in far enough to use 7 inch journals on a 6 feet 9 inch axle. Other roads started out with a larger axle, larger than was really necessary, but adopted it at any rate. The Pennsylvania lines, I think, have axles about 6 feet 11 inches. Now, if we are to have a standard, I consider it is not so much a question as to which is the best size, but which will be the most expedient so as to conform to all the notions and views of the different roads. That being the case I am in favor of the adoption of an axle 6 feet 11 inches in length, which is less than the Master Car Builders' Axle; but my experience has been that more axles have been thrown out of service from worn-out journals than any other cause. We find in repairing our freight cars, axles that are good enough to run for several years but the journals are too small, and I think if we can get 3¾ inches diameter that it is better than 3½ inches, because you can use the axle for years and then it will be 3½ inches. If from any cause the journal requires to be trued up you have something to work on, which may be done several times before the axle is worn out. With these considerations my judgment goes to make the journal 3¾ inches. If there are a number of roads in the country that can make the journal, say 3⅝ or 3½ inches—¼ of an inch will not make any material difference, because on some roads you will find ¼ of an inch difference in diameter of the journals whatever the standard may be—I think we can all conform to this

point if the different roads will adopt the standard length of axle. Leaving out the matter of expediency, I would make the standard axle shorter than the Master Car Builders' for the reasons I have given you, for although a large number of roads prefer an axle 6 feet 11¼ inches and 6 feet 11¾ inches they can all use 6 feet 11 inches.

Mr. JOHANN, Wabash Railroad—Mr. President, I am very much gratified with the remarks of Mr. Wells. If we can all look at the matter in the light that he does we will come out all right.

Mr. WHITE, Evansville and Crawfordsville Railroad—Mr. President, I think if we can get our journals large enough we will have no great trouble with our axles, and after that we will have all the sizes desired.

Mr. HAYES, Illinois Central Railroad—Mr. President, it is a little singular how slow we are to adopt anything new. In 1852, when I took charge of the machinery on the Baltimore & Ohio Railroad, we were using axles 2¼ inches in diameter by 4½ inches long. I recommended to Mr. Parker, the General Superintendent, that we should use a journal 3 inches in diameter and 6 inches long. He consented to take the matter into consideration, and in talking to the President he told him what I had recommended, and the President said, "Why that man Hayes will ruin your road if you let him go on." It went along some time and finally they adopted one 2¾ by 5 inches, and now I believe they are using one 3½ by 7 or 8 inches. In regard to the Master Car Builders' Standard, I do not exactly agree with them as to the size, but I agree with my friend Mr. Wells that we should be very careful not to get too far from the wheel. In our recent experiment, at Chicago, we found a difference between the top and bottom flange of the wheel of nearly $\frac{5}{16}$ of an inch of a spring. Now every time a wheel makes a revolution there is a difference of from $\frac{1}{16}$ to $\frac{5}{16}$ of an inch between the top and bottom of the flange of the wheel, and it is only a question of time when this will break the axle. We have been very fortunate with our axles; I do not know that we have had a journal break since I have been on the road, unless caused by a hot box or something of that kind. I think by adopting the 3¾ inch journal it will add largely to our carrying capacity of cars, and it is only a question of a few years when we will be required to carry from fifteen to twenty tons in a car, and therefore I think we should make the journal large and as close to the wheel as possible.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, I hope the members will all bear in mind that in recommending the Car Builders' length, that if it is not the best, it is the one that may be the most easily adopted and most likely to come into general use. I realize the importance of what Mr. Hayes says about keeping close to the wheel with your journal, but for the sake of recommending an axle that probably a majority of the roads would adopt the Master Car Builders' have adopted *this* axle, and the question now is for this Convention to decide whether we shall make any concession and adopt 83 inches, or whether we will reject it for a

shorter one with the probability that very few companies will adopt it. My own opinion is that we had better adopt the 83 inches, that length having grown out from the necessity of roads using a gauge of 4 feet 10 inches, and they can not well run on a shorter axle, and the expense of changing on the Pennsylvania and several other roads that are using it will be avoided. I hope we will treat this question fairly, and let each member lay aside his own private opinions with the view of doing the greatest amount of good to the greatest number of roads.

Mr. JOHANN, Wabash Railroad—Mr. President, I have used this axle for three years, and in all that time I have never experienced any difficulty from the journals. I think we can get in close enough to the wheel, at least I have experienced no trouble. The inside shoulder of the journal is precisely in the same line with that on our smaller car axles, and we have 3¼ by 5⅝ inch journals. We have had no trouble from the springing of axles.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, I might state that we made a careful test in regard to the springing of the axles, and I had a tracing made to bring with me, but as Mr. Hayes had given the Committee the benefit of his experience I did not think it necessary to bring it. The axle we used was 4⅝ inches in the wheel fit and 4 inches in the center, which placed under a tender loaded with two thousand five hundred gallons of water and five tons of coal we found a variation of ⅛ of an inch between the flanges of the wheel; but so long as there is not a permanent set in the iron I do not think this amounts to much. In the ten thousand cars we have in use many of the axles are small, a majority of them being fitted up with journals 6 by 3¼ inches, and yet our axles give excellent satisfaction. I conceive it would be desirable to work as close to the rail as possible, and I believe Mr. Hayes recommends one inch shorter, 6 feet 10 inches, instead of 6 feet 11 inches, the Car Builders' Standard.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, in the discussion of this subject it seems to me there is one other thing that should be considered, and that is the extension of the hub on the inside of the wheel. The further the hub is extended towards the center of the axle the less strain there will be upon the axle at the inside edge of the hub. As we have in contemplation the adoption of a long axle, it seems to me the hub on the inside might be extended an inch more than the usual distance, and that would to a certain extent compensate for this additional distance on the outside of the rail, and in some degree this spring of the axle in the center.

Mr. JOHANN, Wabash Railroad—Mr. President, I would move that we postpone further discussion upon this question and make it a special order for ten o'clock to-morrow morning.

Mr. HAYES, Illinois Railroad—Mr. President, I second Mr. Johann's motion.

Carried.

THE PRESIDENT—Gentlemen, the next business in order is the report of your Committee upon Lubricants, which the Secretary will please read.

Report of the Committee on Lubricants.

To the Members of the American Railway Master Mechanics' Association:

GENTLEMEN:—The Committee on Lubricants beg to report as follows:

Up to the present date (April 12th), there has been received outside of the reports of the members of the Committee but five replies to the circulars issued. With this very meager, though praiseworthy, stock of information, representing, as it happens, the North, South, East, and West, we compile the following report:

The preference for machinery and journal oils seems to be largely in favor of West Virginia, or other heavy mineral oils, either unmixed or compounded with a certain proportion of animal oils.

Mr. Coolidge, of the Fitchburg Railroad, uses "petroleum, or black oil," as he terms it. Mr. King, of the Western Railroad of Alabama, uses "good West Virginia." Mr. Johann, of the Wabash Railroad, the same; also Mr. Hayes, of the Illinois Central; while Mr. Sedgley, of the Lake Shore Railroad, uses a compound, based on the heavy Franklin, Pennsylvania, oil, as is the case with the Atlantic & Great Western Railroad.

Mr. Ortton, of the Committee, uses both "black oil, partly refined, and lard oil" for machinery, and a mixture of two-thirds black and one-third lard for journal bearings.

For cylinders and valves, some still seem to prefer tallow to anything else, and yet are not satisfied with it, for reasons well-known to all, while others have tried with success special oils.

Mr. King, of the Western Railroad of Alabama, has used a cylinder compound for about a year, and has abandoned tallow. Mr. Coolidge, of the Fitchburg Railroad, while using lard as a rule, is experimenting with a compound which thus far gives "good results." Mr. Sedgley, of the Lake Shore Railroad, has also abandoned tallow, and is using a compound with success.

Mr. Hayes, of the Illinois Central, says: "For valves and cylinders, a lubricant that will satisfactorily fulfill all the conditions has yet to be found. For many years we used tallow for this purpose, but have abandoned it by reason of its injurious effect on the metal

in cylinders and valves. We next tried lard oil; this we found to be an improvement over tallow, but, by reason of its gumming up the exhaust pipes and nozzles, thus gradually reducing the orifice, were compelled to abandon it. We are now using three different so-called cylinder oils, which are doing fairly well; these oils are a mixture of high-test petroleum and animal oils, known only to the manufacturers; the cost is about the same as for lard oil or tallow, and, so far as our experience goes, it is giving better satisfaction than anything else we have tried."

Mr. Ortton, of the Committtee, while using tallow generally, says: "It is but fair to admit that I have seen some very good results from tests of plumbago oils for cylinders and valves, but the shortness of engine power compels us to run our engines continually by different engineers, which precludes us from arriving at positive results."

The experience of the Atlantic & Great Western Railroad has been chiefly with tallow and tallow oil, the latter being especially satisfactory with self-feeding oil cups. Trials are being made with a special cylinder oil, and while not entirely satisfactory it is hoped that it may prove enough better than tallow to justify its more extended use.

Regarding experiments, your Committee have failed to receive reports of any special trials being made by those companies possessing oil-testing machines.

In the matter of self-feeders, now as ever, diversity of opinion exists, the majority favoring oiling from the cab.

Mr. Johann, of the Wabash Railroad, says: "I am using tallow cups inside of cab, placed on boiler head, with seamless brass tubing connecting to steam chest. These operate very satisfactory to me, and I prefer it over all other ways of lubricating valves and cylinders."

Mr. Coolidge, of the Fitchburg Railroad, says: "While the constant lubrication of the valves and cylinders, as attained by the use of self-feeding cups is of great advantage, yet, in consideration of the fact that they are somewhat liable to derangement, I prefer the method of oiling by means of cups placed in the cab."

Mr. Hayes, of the Illinois Central, says; "We prefer oiling valves from the cab, so the engineer may see that the fireman does not waste the oil. We had at one time a large number of self-feeding

oil cups on the steam chests of our engines, but they proved very unreliable in cold weather and were finally abandoned."

Mr. Ortton, of the Committee, says: "I prefer self-feeders where they can be protected and kept in good working order during severe winter weather. With us this is difficult to do, and so we adopt cups inside of cabs as the next best feeders."

On the Atlantic & Great Western Railroad they prefer the method of oiling from the cab, as best adapted to general use, but on engines hauling fast passenger trains, and run by first-class engineers, they consider the self-lubricating cup can be used to good advantage.

Your Committee regret the limited returns from which to make up a report, and can conceive of no reasonable excuse for neglect in this respect, for even the statistics of service performed, and cost of same, so easily furnished, would, if complete for all or a majority of our lines, afford interesting data for discussion, and possibly lead to valuable conclusions.

Below is given the figures of those who did report, viz:

The Committee respectfully submit the subjoined letter of Mr. Hewitt as a part of this report.

MISSOURI PACIFIC RAILWAY COMPANY,

[Office Superintendent of Motive Power and Machinery.]

ST. LOUIS, April 27, 1879.

WILLIAM FULLER, ESQ.:

Dear Sir—Referring to the "Circular on Lubricants," I beg to say, for several years past we have been using petroleum oil for lubricating our locomotives, and lard oil for cylinders. During the year 1878 our locomotives run 2,541,594 miles and consumed 10,668 gallons of petroleum oil for machinery and journals, and 6,624 gallons lard oil for cylinders. The cost of the petroleum oil was $1,812.46, and lard oil, $3,622.69. This made an average of thirty miles run to one pint of petroleum oil, and forty-eight miles run to one pint of lard oil for cylinders; and a cost of .0007 cent per mile run for petroleum oil, and .0014 cent per mile run for cylinder oil.

We perfer to use the above kinds because they are economical and suitable for the purposes.

Statement of Service of Lubricants for Locomotives and Cost per Mile of Same for Year 1878.

LUBRICANTS FOR MACHINERY, ETC.

RAILROADS.	KIND.	Miles Run per Pint.	Quant. used pr. 100 miles	Cost per Mile Run.	Cost pr. 100 Miles Run.
Atlantic & Great Western Railroad	Franklin Oil, compounded	34.50	2.8 pints	0.10 cts.	10 cents
Canada Southern "	Black and Lard Oil	25.00	4.0 "	0.04 "	4 "
Fitchburg "	Petroleum or Black Oil	†	*	*	*
Illinois Central "	West Virginia Oil	37.36	2.6 "	0.04 "	4 "
Lake Shore "	Franklin Oil, compounded	‡	*	‡	*
Wabash "	West Virginia Oil	28.17	3.6 "	0.048 "	4.8 "
Western Railroad of Alabama	"Good" West Virginia Oil	44.53	2.2 "	*	*

LUBRICANTS FOR CYLINDERS.

RAILROADS.	KIND.	Miles Run pr. pt. or lb.	Quant. used pr. 100 miles	Cost per Mile Run	Cost pr. 100 Miles Run.
Atlantic & Great Western Railroad	Tallow and Tallow Oil	52.80	1.8 lbs.	0.13 cts.	13 cents
Canada Southern "	Tallow	34.50	2.8 "	0.23 "	23 "
Fitchburg "	Lard Oil	†	2.5 pints	*	*
Illinois Central "	Cylinder Compound	59.82	1.6 lbs.	0.115 "	11.5 "
Lake Shore "	Cylinder Compound	‡	*	‡	*
Wabash "	Tallow	43.71	2.3 "	0.18 "	18 "
Western Railroad of Alabama	Cylinder Compound	44.47	2.2 "	*	*

* Not reported.
† Not given separately. Average per pint all used 19 miles.
‡ Not given separately. Average per pint all used 23.42 miles. Cost per mile all used 0.21 cents.

We have a preference for placing oil cups inside of cab for lubricating cylinders.

Very respectfully,

JOHN HEWITT, Supt Machinery.

Respectfully submitted,

WM. FULLER. *Gen'l M. M., A. & G. W. R. R.*
F. M. WILDER, *M. M., N. Y., L. E. & W. R. R.* } *Committee.*
JOHN ORTTON, *Mech. Supt., C. S. R. R.*

On motion, the report was received.

THE PRESIDENT—An opportunity is now offered for any discussion that may be desired.

Mr. ORTTON, Canada Southern Railroad—Mr. President, this subject does not appear to be very interesting, although I think it ought to be, as much of the durability of axles, of which we have been talking, depends upon good lubrication. There is one thing in this report that I think is very important, and that is the recommendation of the natural oils for general lubricating purposes. About three years ago we were using a quality of oil we considered best adapted to our needs, which cost 80 or 90 cents per gallon; after a while we tried a patent oil, and finally changed from that to the natural oils, from which we get very good results, a great deal better than we derived from the patent oil. The natural oil costs from three dollars to three dollars and a half a barrel, which brings the price per gallon down to a very low figure, and we can run more miles with the same quantity than we could with the oils for which we paid 80 or 90 cents per gallon. We saved four or five hundred dollars in a very short time by the substitution of the natural oil, which we thought worth saving, and this fact makes this part of the report very interesting to me. We have also used plumbago oil for cylinders, which has given very good results.

Mr. HAYES, Illinois Central Railroad—Mr. President, I would like to ask Mr. Ortton if the use of plumbago oil in engines did not give trouble by stopping up the oil pipes in the cab.

Mr. ORTTON, Canada Southern Railroad—Mr. President, yes, sir, it does give some trouble in that respect unless you are very particular to keep them blown through.

Mr. HAYES, Illinois Central Railroad—Mr. President, that was the trouble I found with plumbago, and for that reason I had to abandon it; and in regard to lubricating oils, I would like to say that some twenty years ago we paid 80 cents per gallon for machinery and journal oil, and now we can get oil for 12½ cents per gallon which gives much better lubrication than that for which we paid 80 cents and it lasts longer. Hence we can imagine the saving that can be made in oils.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President,

I am very glad to hear the results the gentlemen have stated in regard to the use of natural oils for locomotives. Three or four years ago we made some tests with our oil-testing machine, which were very favorable to the natural oils, and we have been governed ever since by the results obtained. For the last year we have not used any lard or animal oil of any kind, our experience being that mineral oils give the best results. I would like to hear an expression of the members present as to their experience in this matter.

On motion, the discussion upon this question was closed.

THE PRESIDENT—If no objection, the next business in order will be the report of your Committee on Correspondence received thus far.

The Secretary then read the report.

Report of Committee on Correspondence.

Your Committee on Correspondence respectfully beg leave to recommend that the communication of Mr. L. Williams, General Manager of the C., H. & D and C., C., C. & I. Railroads, extending an invitation to visit Dayton and the Soldiers' Home, be read.

JAMES SEDGLEY,
WILLIAM FULLER, *Committee.*
J. F. DEVINE,

THE PRESIDENT—Gentlemen, you have heard the report of your Committee, but I would like to state to the members, before a vote is taken, that several years ago a resolution was passed by the Association that no action should be taken upon any communication presenting any form of entertainment to the Association.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I do not think it would be well to bring it before the Convention; but it seems to me that we might accept this communication and order it filed, and as soon as we adjourn the Chairman can call the members to order and they can then express themselves individually as to whether they desire to accept the invitation or not.

Mr. KING, Western Railroad of Alabama—Mr. President, if we can not entertain the proposition at all as an Association, all we can do in the case is to refer it back to the Committee.

Mr. WEAVER, Eastern Kentucky Railroad—Mr. President, I think it would be no more than an act of courtesy to accept the proposition.

THE PRESIDENT—Article V, Section 5, of the Constitution declares that no communication shall be received during business sessions that does not pertain to the business of the Association. After our adjournment an informal meeting can be held, and then such action can be taken as the members think best. If there is no objection, it will be so understood. We have an appli-

cation for Associate Membership from Mr. John W. Hill, a gentleman who recently conducted experiments in this city, which were printed in the city papers and also in the journal of the Franklin Institute.

On motion, the application was referred to a committee consisting of Messrs. Hayes, Johann, and Flynn.

THE PRESIDENT—Gentlemen, it has been suggested that we have an extra session this afternoon, from half-past three until five o'clock. If the members desire it, it will be necessary for some one to make a motion to that effect.

Mr. HAYES, Illinois Central Railroad—Mr. President, I move we suspend the rules and hold an extra session from half-past three to five o'clock this afternoon.

THE PRESIDENT—You have heard the motion of Mr. Hayes; are there any remarks?

Mr. SETCHEL, Little Miami Railroad—Mr. President, I would say for the information of the members that we have only two reports on hand. One of them, it is true, is very long; but I think with our three days' session we will have plenty of time to do our work, and it seems to me unnecessary to hold an extra session this afternoon. We have now been in session five hours, and as this is our first meeting in Cincinnati, perhaps some of the members would like to look around our city, and have some time for social communication, and I hope the motion will not prevail.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, I hope the motion will prevail. My opinion is that we save too much business for the last day, which makes it very unpleasant and difficult to do it properly, and as there is a large number of members here for an afternoon session, I hope the Convention will see fit to adopt the motion of Mr. Hayes.

Mr. HAYES, Illinois Central Railroad—Mr. President, my object in making the motion was, that as we have two or three applications for Associate Membership to be disposed of by ballot, which will consume a good deal of time, and there are also other matters of similar importance that it would be well to dispose of early in our proceedings, so as to save a rush of business on the last day, when the election of officers and other important business will be on hand, which we will wish to conclude in the most satisfactory manner.

Motion carried.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I move that we now adjourn.

Motion carried.

AFTERNOON SESSION.

The Convention was called to order at 3.30 P. M.

THE PRESIDENT—We have two more applications for Associate Membership, which the Secretary will please read.

The Secretary then read the application of Charles A. Smith for Associate Membership, recommended by Jacob Johann, B. Warren, and Henry Elliott; also the application of J. H. Raymond, recommended by S. J. Hayes, James Sedgley, and R. Wells.

THE PRESIDENT—According to our Constitution these names must be referred to a committee. For the committee to consider the application of Mr. Smith, I will appoint Mr. White, Mr. Simonds, and Mr. Cook, and for Mr. Raymond, I will appoint Mr. J. M. Boon, Mr. H. L. Cooper, and Mr. Robert King. Mr. Hayes would like to say a word in regard to Mr. Raymond, and I hope the committees will prepare to make their reports as soon as possible.

Mr. HAYES, Illinois Central Railroad—Mr. President, I am one of the gentlemen who have recommended Mr. Raymond for Associate Membership in this Association, and it, perhaps, is proper that I should say what I know of him. He is a young man, a lawyer, and Secretary of the Western Railway Association. He is an expert mechanic and familiar with our department of railroads, and I think he will be a very useful member, and will be able to give the Association a great deal of valuable information.

THE PRESIDENT—I will state that the Finance Committee, consisting of Mr. Richards, Mr. Johann, and Mr. J. Davis Barnett, are ready to receive the assessment of any member wishing to pay his dues. Mr. Richards is Chairman, and will be pleased to see you. It has been our custom early in the proceedings to appoint a committee to select places to be voted upon for holding our next Annual Meeting. It would be well to do this this afternoon, in order that the committee may report to-morrow.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I move that a committee of three be appointed to select places to be voted upon for holding our next Annual Meeting.

Motion carried.

THE PRESIDENT—I will appoint upon that committee, J. Davis Barnett, John Swift, and J. F. Devine. Your committees appointed to report respectively upon the applications of J. H. Raymond, Charles A. Smith, and John W. Hill, for Associate Membership, are ready to report.

The reports were read, and the committees reporting favorably, ballot was taken which resulted in the election of the above named gentlemen to Associate Membership.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I desire to speak of a little matter that I may as well mention now, and that is, our Fourth Annual Report is out of print. I have never been able to get a copy, and pre-

sume many other members would like to have one. I would like the whole series for the purpose of binding, and would be willing to pay a good price for this number.

THE PRESIDENT—I noticed in the reading of the Secretary's report to-day that there is none of the Fourth Annual Report on hand. It may be the Secretary can give us some information as to the probable cost of printing three or four hundred copies.

THE SECRETARY—Mr. President, there are 105 pages in the Fourth Annual Report, and it would probably cost from $250 to $275 to print and bind three or four hundred copies. We have had a great many applications for this number, but it has been out of print for three years.

Mr. SPRAGUE, Porter, Bell & Co.—There seems to be but little interest in the matter, and may be we had better drop the subject, although I would like very much to have a copy.

THE PRESIDENT—Any further remarks upon this subject?

No action was taken, and the Convention resumed other business.

THE PRESIDENT—It has been our custom to appoint a Committee on Subjects for Consideration, and, perhaps, we had better appoint that committee now, so that a report can be made to-morrow at this time.

Mr. HAYES, Illinois Central Railroad—I move a Committe of Five be appointed to Select Subjects for Discussion at our next Annual Convention.

Motion carried.

THE PRESIDENT—I will appoint on that committee, Mr. Ortton, Mr. Fuller, Mr. Johann, Mr. Devine, and Mr. Richards. It has also been our custom to appoint a Committee upon Resolutions; on motion that committee will be appointed.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I move a Committee be appointed on Resolutions.

Motion carried.

THE PRESIDENT—I will appoint on that committee, Mr. Sedgley, Mr. Sprague, and Mr. Hewitt. I would suggest the propriety of appointing a committee to draw up suitable resolutions expressing the sense of this Association in regard to the death of Mr. B. F. Morse.

Mr. SEDGLY, Lake Shore & Michigan Southern Railroad—Mr. President, I move that a Committee be appointed to draw up Resolutions on the death, of Mr. Morse.

Motion carried.

THE PRESIDENT—I will appoint on that committee, Mr. Johann, Mr. Boon, and Mr. Ray,mond, our newly elected Associate Member. This resolution will be in the form of a memorial, giving a short sketch of Mr. Morse's life, which can be drawn up and sent to the Secretary after adjournment. The next business in order is the Report of the Committee upon the Best Material, Method,

Form, and Proportion in Constructing Locomotive Boilers. As the report is very long, and it is nearly five o'clock, it is hardly worth while to take it up this afternoon, and if it is the wish of the members a motion to adjourn will be in orde.

Mr. SPRAGUE, Porter, Bell & Co—I move we adjourn until the usual hour to-morrow morning.

Motion carried, and Convention adjourned.

SECOND DAY'S PROCEEDINGS.

President CHAPMAN in the chair.

The Committee on Correspondence reported a communication received from the Cincinnati Chamber of Commerce, extending the privileges of the floor of that body to the members of the Association during their stay in the city, which was read and received, and the Secretary instructed to acknowledge the same with the thanks of the Association therefor.

THE SECRETARY—Mr. President, we have a short report on the subject of the Best Material for Locomotive Wheels and Axles, which being very closely connected to the subject of the special order set for 10 o'clock, I would suggest that it be read at this time.

THE PRESIDENT—If there is no objection the Secretary will please read the Report of the Committee upon the Best Form and Material for Locomotive Wheels and Axles.

The Secretary then read the report.

Report of Committee on the Best Form and Material for Locomotive Wheels and Axles.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee appointed to investigate the subject of the Best Form and Material for Locomotive Wheels and Axles, have carefully considered the same, and submit the following as the result of their labors. In discharging their duty your Committee deemed it important to get the views of persons whose experience entitle them to consideration, and with this view the following circular was issued to the members of the Association:

COMMITTEE CIRCULAR.

To Members of the Master Mechanics' Association:

The undersigned were appointed a Committee to investigate the

subject of the Best Form and Material for Locomotive Wheels and Axles. In order to obtain the necessary information from which to make this report they would respectfully solicit replies to the following questions, and at the same time urge all the members to make prompt and full replies, as upon them depends the nature of our report:

ENGINE TRUCKS.

1st. How many engines have you equipped with cast-iron wheels in engine truck?

2d. How many with cast wheels, centers, and steel tires?

3d. How many with cast wheels with steel faces?

4th. Have you any other kinds in use?

5th. How do these compare for first cost and for cost of maintenance per mile run?

6th. For this purpose please state what description of wheels you recommend, and whether you prefer spoked, single, or double-plated wheels.

7th. How many wheels of each kind have broken in service in the past two years in engine truck; state also (if known) the cause of breakage.

DRIVING WHEELS.

1st. What kind of wheel centers do you recommend for driving wheels? Hollow spokes with hollow rim and nave or hub, or solid spokes with solid rim and hub, or solid spokes with hollow rim and hub?

2d. Please state if you have had any wheel centers broken within the past two years and of what kind?

TENDER WHEELS.

1st. How many engines have you equipped with cast-iron tender wheels?

2d. How many with cast centers with steel tires?

3d. How many with cast wheels with steel faces?

4th. Have you any other kinds in use?

5th. Which gives the best result in miles run, including first cost and cost of maintenance?

6th. For this purpose what wheels would you recommend?

7th. Have any tender wheels broken in the past two years? If so please state the kind and cause of breakage.

TRUCK AXLES.

1st. What are your standard sizes for journals for engine-truck axles on engine of 16 by 24 inch cylinders? Give also size of wheel seat.

2d. How many engines have steel and how many have iron axles in engine truck?

3d. Which gives the best results considering first cost, wear of journals and brasses and cost of lubricants?

4th. Which gives the best results iron or steel all things considered, and what dimensions would you recommend?

5th. Have any engine-truck axles broken in the past two years, if so please state kind and cause?

DRIVING WHEEL AXLES.

1st. What are the dimensions of driving-wheel axles for American engines 16 by 24 inch cylinders? Give size of journals, wheel seat and center of shaft, and whether straight or tapering to the center.

2d. How many engines have you with steel and how many with iron axles?

3d. Which gives the best results considering first cost, wear of journals and brasses and costs of lubricants?

4th. Have any axles broken in the past two years? If so please state what kind and what part of the axle broke first? If convenient send sketch.

TENDER AXLES.

1st. What are the dimensions of your standard tender axles, including size of journal, length of axle, size of wheel seat and diameter of axle in center?

2d. How many tenders have iron axles, how many have steel axles?

3d. Which gives the best results all things considered?

4th. Which would you recommend for tender axles, iron or steel, and what in your opinion are the best dimensions for this purpose?

5th. How many tender axles have broken in the past two years, and of what kind?

VALUABLE SUGGESTIONS.

Please give any information which you may have that will help the Committee in making up their report. They will be pleased to receive tracings (on small scale) of standard axles for engine and tender trucks.

Replies to the foregoing questions are solicited before March 1st, 1879, and should be addressed to Robert King, Master Mechanic Western Railroad of Alabama, Montgomery, Alabama.

Very respectfully,

ROBERT KING, *W. R. R. of Ala.*
WILLIAM RUSHTON, *A. & W. P. R. R.* } *Committee.*
JAMES MAGLENN, *Car. Cent. R. R.*

To this circular only nine replies have been received from Master Mechanics.

ENGINE TRUCK WHEELS.

In engine trucks, four use nothing but cast-iron wheels; in addition to cast-iron wheels four have in use cast wheel centers with steel tires (350 wheels reported); three have in use cast wheels with steel faces (238 wheels reported); and one has in use solid steel wheels (number not given); those using cast wheels only have no data for comparison. One member using steel-tired wheels thinks the difference in cost small, but considers the steel-tired wheel safer; another member considers the steel-tired wheel as four to one of cast-iron; another thinks the first cost of the steel-tired wheel against it, in comparison with iron; five prefer spoke wheels, and four double plate; the former giving as a reason that they allow a better inspection of the truck and its parts, and afford better access in oiling, while those preferring the latter think the spoke wheels fan up the dust more and cause the brasses to wear faster.

Your Committee have reports of three steel-faced wheels and seven cast-iron broken in the tread, although no damage to engines is reported.

DRIVING WHEELS.

Of those replying to our circular, four prefer hollow-spoke, hub, and rim; one solid spoke and rim, and two solid spoke and hub and hollow rim; two have both kinds in use, and both do well, therefore have no choice.

Your Committee have reports of nine broken wheels, all of hollow spokes.

TENDER WHEELS.

In tender trucks, six use nothing but cast-iron wheels; in addition to cast-iron wheels three use cast centers with steel tires (292 wheels reported); two have in use cast wheels with steel faces (116 wheels reported); one has in use Bochum cast steel (number not given); of those using steel-tired wheels under tenders, one prefers cast-iron; one prefers steel-tired, and one prefers steel-faced wheels.

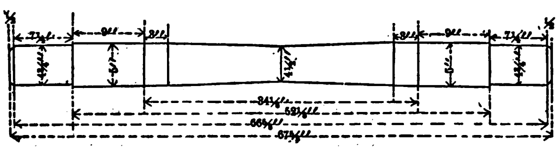
Thirteen wheels are reported cracked and broken, all of cast iron; no damage reported, as they broke in the tread and flange.

TRUCK AXLES.

From replies to our circular, we learn the desire of the members is to increase the size of journals; seven are using journals 4½ inches in diameter by 7 to 8 inches long; one uses 4⅝ by 8 inches; and one 5 by 9 inches; (see sketch). For wheel seat the sizes vary from 4½ to 4¾ inches in diameter; only two report as having steel, and recommend its use.

No axles are reported broken.

Wabash Railroad Engine Truck Axle.



DRIVING AXLES.

The dimensions of journals for driving axles reported are from 6½ by 7 to 7 by 8 inches. All use iron; two have steel in use; one uses it for crank axles, and another has thirty-four engines with steel axles. Those using steel for driving axles prefer it for that

purpose, as giving better results than iron. We find from the replies that a majority use a parallel axle; while one recommends to enlarge the axle in the middle, especially for back axles, thereby making it more rigid.

Four back and two front axles are reported broken, four of which had been in service for ten years and broke close to the hub.

TENDER AXLES.

From the replies to our circular we learn that the desire is to increase the sizes of tender axle journals rather than diminish them. Three are using the Master Car Builders' Standard, while the others are using journals from 3¼ by 7 to 3½ by 6½ inches. All are using iron; one is using steel under three tenders; two of those who have used steel prefer it for tender axles.

Four iron axles are reported as broken, one at the hub of wheel and two at the journal.

The following is given by Mr. W. O. Hewitt, of the Toledo, Peoria & Warsaw Railroad, showing the advantage of the Master Car Builders' Standard Axle over the smaller journal. One 2,400 gallon tank, with Master Car Builders' Axles, ran 73,650 miles, and cost for lubrication and waste $2.27; and another 2,400 gallon tank, with axles having 3¼ by 5½ inch journals, ran 74,730 miles, and cost for lubication and waste $7.27.

Your Committee believing that all the members are more or less familiar with the mileage made by cast-iron wheels, the following is given by Mr. George Richards, of the Boston & Providence Railroad, showing the mileage made by steel-faced and steel-tired wheels, etc.:

Four Bochum cast-steel wheels, under a heavy tender, ran 142,260 miles and were in good condition. They had not been turned, and the wheel was heavy enough on the tread for three turnings.

A pair of paper wheels, under a light tender, making many stops, ran 125,941 miles and were in a fair condition. A pair of cast-iron wheels, run as mates to the paper wheels, made 91,062 miles and were worn out.

A pair of steel-faced wheels, in heavy engine truck, made 50,123 miles on the first run, and a total of 121,929 miles and were condemned.

Another pair of steel-faced wheels, in heavy engine truck, ran 47,034 miles after first turning and were condemned.

Two pairs of steel-faced wheels, in heavy engine truck, made 79,905 miles first run, and 129,587 miles to date and were in good condition.

Another pair of steel-faced wheels, in heavy engine truck, made 71,852 miles first run, and 41,266 miles second run, total 113,118 miles and were condemned.

Another pair of steel-faced wheels, under heavy tender, made only 31,372 miles the first run.

One pair of steel-faced wheels, in engine truck, made 38,932 miles the first run.

One pair steel-faced wheels, in engine truck, made 64,750 miles the first run.

Your Committee concur in the report of last year's Committee with regard to the dimensions of engine and tender truck axles and of driving axles, except the shoulder at the wheel seat.

In addition to the circulars sent to Master Mechanics circulars were sent to eight locomotive builders and others. Two replies were received from the above.

One builder has equipped 247 engines with cast-iron wheels in engine truck; 28 engines with cast wheels and steel tires; 23 engines with cast wheels and steel faces, and 1 engine with paper wheels.

They have equipped 264 tenders with cast-iron wheels and 13 tenders with cast centers and steel tires.

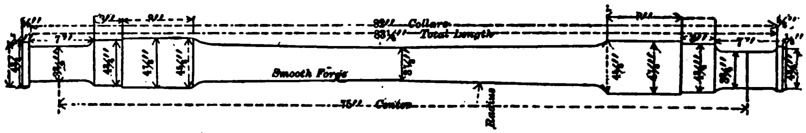
They have equipped 228 engines with iron truck axles; 70 engines with steel truck axles; 412 engines with iron driving axles; 46 engines with steel driving axles; 230 tenders with iron axles, and 47 tenders with steel axles.

It will be observed that replies to this circular show that steel is being used for axles on a number of roads.

All of which is respectfully submitted.

ROBERT KING, *M. M., W. R. R. of Ala., Montgomery,*
WM. RUSHTON, *M. M., A. & W. P. R. R., Atlanta,*
JAS. MAGLENN, *M. M., Car. Cen. R. R., Laurenburg,*
} *Committee.*

Standard Tender Truck Axle, Lake Shore & Michigan Southern Railroad.



[A tracing of axles, showing the standard engine truck and tender axle in use on the Wabash Railroad, was presented with the report.]

On motion of Mr. Sedgley the report was received.

THE PRESIDENT—An opportunity is now offered for discussion upon the report.

Mr. KING, Western Railroad of Alabama—Mr. President, as Chairman of that Committee I would state that we received but nine replies to our Committee Circular, and from the information contained in them we could add but little to the report of last year upon standard axles, especially as there was another committee covering nearly the same ground to report this year. You will notice by the report, that on engines 17 by 24 there is a tendency to enlarge the tender axle and increase the size of the journal. We solicited information from a great many locomotive works, but received no replies. I consider that many of the gentlemen representing these works could give us information if they would. Some of them were formerly Master Mechanics, and have a valuable experience in operating machinery, and I regret exceedingly that we did not hear from them.

THE PRESIDENT—It is now ten o'clock, and the special order set for that hour is in order; but before discussion upon that subject is resumed, allow me to say that Mr. Johann, Chairman of Committee upon Subjects for the ensuing year, will be glad to receive suggestions as to suitable subjects for consideration at our next annual meeting. Discussion upon Standard Car and Tender Axles is now in order. Mr. Johann, Wabash Railroad, has the floor.

Mr. JOHANN, Wabash Railroad—Mr. President, my object in making the motion to postpone the discussion of this question was to give all the members time to sleep and think over the matter. As for myself I am not going back upon anything; but, as I said yesterday, the time is coming when we will have to use a larger axle than we do now. Just what the size will be I am not prepared to say; but I would like to see this Association adopt the Master Car Builders' Standard now as the first step in the right direction. We will have to come to it sooner or later, and I would like to hear all the members express their opinion, and then let us decide the matter so far as this Association is concerned. I shall vote for the Master Car Builders' Standard.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—In regard to the Car Builders' Standard Axle, I think it would be difficult to determine just exactly what that size is, as there is so much difference in the weight,

varying from 330 to 350 pounds. I think the axle is being put in on the leading roads at about 330 pounds.

Mr. Boon, Pittsburgh, Ft. Wayne & Chicago Railroad—Mr. President, I was not present when this discussion opened, but I understand the first part of it was whether we should adopt the Master Car Builders' Standard. I do not object to a large axle; but I do object to the Car Builders' size, for the reason that it can not be used on all roads. Now if you increase the size of journal to 3½ or 3¾ inches, you will have to make an entire change in all your cars in the oil boxes and brasses, and I doubt very much whether any road is going to change their entire equipment for the sake of getting a standard. For instance, on our road we have an equipment of twenty thousand cars; now to change these cars would require us to increase our stock to such an amount as no road in the country can stand. The expense necessary to make such a change would be so great that I think it will be utterly impossible for it to be done; besides we are hauling very heavy loads with our present size of axle. I do not think any of us will live to see this axle come into general use.

Mr. Simonds, Cairo & St. Louis Railroad—Mr. President, I am reported in the morning papers as being in favor of 3¼ by 6 inch journal. I would like to correct that statement. When I was on a road in the East some of the journals were 3 by 5½ inches, and others 3¼ by 6 inches, and we carried pretty heavy loads upon them, and none of them ever broke that got fair usage. The question to determine is, whether we gain by increasing the size of the journal. Mr. Sedgley says he is in favor of a 3½ inch journal. My preference would be for 3½ by 7 inches. Now let us consider the immense amount of rolling stock controlled by the eighty thousand miles of railroad scattered through the country, and we figure up into the millions in axles, which shows that it is no small matter for this Convention to decide that they will adopt this or that axle. The 3¼ inch journal, with 4⅞ inch wheel seat, will add millions of pounds weight to our rolling stock, and in many cases necessitates an entire change in our trucks and oil boxes to get in our wheels. It is as Mr. Boon says, there is not a man on this floor that will live long enough to see this standard axle come into general use even if we do adopt it. I have no doubt that a standard would be of great benefit, but to adopt one will involve more expense than most roads would be willing to stand. I think a 3¼ inch journal is sufficient to carry any weight that may be required; but I still think 3½ inches will give much better service.

Mr. Johann, Wabash Railroad—Mr. Boon imagines that no man here will live to see the standard axle adopted on all roads. Now while I do not mean to say that every man here will live to see it come into general use, still I am perfectly satisfied that some of us will. There is no extraordinary expense attending it if properly managed. All of us know that we have to make more or less renewals every year, and whenever an axle gives out it

can be replaced with a standard axle without any extra expense. By adopting it it is not expected we will say to our superior officers that we are going to use this axle exclusively; but we can say that in our judgment it is the best, and when we make renewals we can put in this axle, and I can assure you that you will be utterly surprised to see how fast it can be introduced. It will be like the Erie and other roads changing their gauge.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, I would like to ask if any member has adopted the Master Car Builders' Standard for tenders? It seems to me the only question that we should discuss here is a standard for tender axles, and let the Car Builders settle upon a car axle.

Mr. BOON, Pittsburgh, Ft. Wayne & Chicago Railroad—Mr. President, what my friend Johann says with regard to introducing the standard may be true. In that way we could change our entire equipment without much extra expense; but I doubt very much whether we will get more service out of the Car Builders' Standard than our present one.

Mr. ORTTON, Canada Southern Railroad—Mr. President, in my opinion the point is whether we will have a tender axle that will conform to the Car Builders' Car Axle. The Master Car Builders have adopted a standard axle, and it is a question for us to decide whether we will adopt one to conform to their's. They have shown a disposition to compromise with us, and it seems to me that we should confine our discussion entirely to tender axles, and see if we can agree upon something, and, if possible, adopt their standard. When we build boilers or bridges we allow a margin of strength for safety, and I am in favor of the Car Builders' Standard on that account. I think we will all live long enough to see it come into general use.

Mr. ROBERTSON, Marietta, Pittsburgh & Cleveland Railroad—Mr. President, three years ago when I took charge of our road, I found four different sizes of axles under our cars and tenders; some with journals 3¼ by 7 inches and 6 feet 11 inches long, and I also had some of the Car Builders' Standard. I immediately adopted a standard, and now I have all engines equipped with uniform axles. I do not think there is so much objection to the size of the journal as in the total length of the axle. I am in favor of a standard, whether it shall be 3¼, 3½, or 3¾ inches. If you get a good large journal you can run your cars with safety.

Mr. JOHANN, Wabash Railroad—Mr. President, I think, perhaps, we have obtained as much information as possible out of this discussion, and in rising to move that we, as an Association, adopt the Master Car Builders' Standard Axle, I would say that I hope all the members will look at the matter in a practical light. We have had this question under consideration for several years, and I think it is about time to make up our minds. If we adopt this axle it will be the first point towards obtaining a uniform standard for every car and tender in the country. The Master Car Builders' adopted a standard some years ago, and there is no impropriety in this Association endorsing their action. I have felt the importance of a step of this kind for several

years, from the fact that I have had a great deal of additional labor and expense put upon me by having to keep a variety of axles on hand in order to repair foreign cars. When I took charge of the road I am now on we had eight different patterns of tender trucks and as many different axles to correspond. You can readily imagine something of the labor and stock it required to keep a sufficient number of wheels and axles fitted up ready to be used in case of a breakage. I immediately went to work to remedy this matter, and on making examination of the Master Car Builders' Standard Axle, I came to the conclusion that if they adopted it I could use it. I did not throw away any good axles, but when I took an engine into the shop for repairs, if the trucks were pretty well run down I took them out and put in the standard trucks. It has now been five years since I began, and to-day all our engines have Standard Trucks and Axles. In accomplishing this I did not find it necessary to work our men overtime.

Mr. ROBERTSON, Marietta, Pittsburgh & Cleveland Railroad—Mr. President, I would state that I make all axles 3½ inches, although some of them will wear down to 3¼ inches. You, of course, see that I can get 3½ inch brasses on to a 3¼ inch journal; for that reason I make all the new axles 3½ inches.

Mr. JOHANN, Wabash Railroad—Mr. President, I move that we adopt the Master Car Builders' Standard for car and tender axle.

Mr. HAYES, Illinois Central—I second the motion.

THE PRESIDENT—Gentlemen, a motion has been made and seconded that the Master Car Builders' Standard Axle be recommend by this Association for Standard Axle for tenders and cars. Are you ready for the question?

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, before the question is put I would like to ask if that accepts the supplementary report. I do not think that was disposed of yesterday.

THE PRESIDENT—We received both reports.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, then if we adopt Mr. Johann's motion, we will then have adopted the supplementary report.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, any action this Convention may take in reference to adopting a standard axle will simply be an expression of opinion. It has no further authority or weight except an opinion of the Master Mechanics' Association. This subject of standard axle has been presented to the Convention a number of years. It has been discussed from year to year as to what length of axle and size of journal would come nearest to suiting the majority of the railroads in the country, so that they might make the change without extra expense. Now if a new road is to be built, and they want to know which is the best axle, our verdict simply recommends this as being the nearest to all other roads. Whether the standard is adopted or not by any one or more roads would be a question for the authorities of such roads to answer, but they would take the action of this Association as an expression

of an opinion as to what we believe to be the best, and if any old road sees proper to adopt it they will do so. There are a great many roads that renew their equipment every few years, and new roads are being built every year, and as they put on new equipment they can adopt the standard, and the action of this Convention may have some influence upon these points; but whether a majority of the roads adopt it or not, it is right and proper for us to express our opinion upon the subject, and that is as far as we can go. Now if we adopt a certain size we should make the size large enough to answer all purposes, as few use an axle so large as the one recommended, but they can use a smaller one in the same boxes and will be no worse off than we are now. You can have your boxes large enough and there will be no trouble. The important thing in this question is the length, it is of more importance than the diameter. Those roads using a large axle could certainly use a smaller one.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I agree with Mr. Wells that what we want to do is simply to establish our opinion and put it on record, so if a road wishes to know what we think is the best standard axle, we have some definite conclusion to offer. Three years ago we came to the conclusion a standard should be adopted, and we thought a journal 3½ by 7 inches was fully large enough for the service at that time and we adopted that size. Now economy is the watchword, and to change that size would involve a very great expense, and for this reason it would be difficult for any road that has adopted the Master Car Builders' Standard to make a change. Still I am in favor of a standard axle if it can be adopted without extra expense.

Mr. JOHANN, Wabash Railroad—Mr. President, I do not see that there is any economy or policy in going back a fractional part of an inch; I propose to run my axle journal down to 3½ inches, and in putting in new ones I will use 3¾ inches. As for compelling any road to adopt it, that is something we have nothing to do with, and so far as I am concerned I have nothing more to say upon the subject.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, if it is in order I will move an amendment to Mr. Johann's motion that the axle be 3½ instead of 3¾ inches.

THE PRESIDENT—Mr. Johann, do you accept the amendment?

Mr. JOHANN, Wabash Railroad—Mr. President, no, sir, I will not accept anything of the kind so far as I am concerned.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I suggest that we compromise by adopting the standard in length and make the journal from 3½ to 3¾ inches.

Mr. JOHANN, Wabash Railroad—Mr. President, no, sir, I will not compromise on anything. I will vote to adopt the Master Car Builders' Standard Axle and then let those who want to use 3½ inch journals do so, and those who want to use 3¾ inches can do so.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, if I want an extra quarter of an inch I can make my journal $3\frac{3}{4}$ inches, and when they wear down to $3\frac{1}{2}$ inches I will then have a size that is in use on a large number of railroads, for where you will find five or six axles of this kind in use you will not find one of the Master Car Builders'. We can cut off $\frac{1}{8}$ of an inch and then we will have an $\frac{1}{2}$ inch collar and leave off this extra $\frac{1}{4}$ of an inch in length, and here I would like to ask Mr. Johann, as he is the missionary of the standard axle, what this extra $\frac{1}{4}$ inch is for?

Mr. JOHANN, Wabash Railroad—Mr. President, I am a missionary in this cause, but I was not the midwife when the standard axle was born, and can not say how it was worked out, unless it was to get a larger collar. Mr. Wells is perfectly at liberty to do as he suggests. I know there are some roads that use a half inch collar. There is no necessity for making it more than $\frac{1}{2}$ an inch, for that will stand a great deal of strain, and I think we can do very well without the extra $\frac{1}{4}$ inch.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I understood from my friend Johann that there was no compromise in him.

Mr. JOHANN, Wabash Railroad—Mr. President, I say no compromise in the expression of our views here. What we want to settle in this question is, that we respect the Master Car Builders' Standard and adopt it. That is what I propose to not compromise; I want to see this question decided right here.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, the difficulty of settling this question seems to be in the length of the axle, which I think should be left to the judgment of the Master Mechanics; I think the members should vote upon this question at once and settle it.

THE PRESIDENT—Mr. Black, your amendment is not accepted by Mr. Johann; the question is now upon the original motion. Your amendment was that the journal should be $3\frac{1}{2}$ instead of $3\frac{3}{4}$ inches, and you approve the Master Car Builders' Axle with that exception Am I correct?

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, yes, sir.

Mr. ORTTON, Canada Southern Railroad—Mr. President, for tender axles?

THE PRESIDENT—Yes, sir, for car and tender axles.

Mr. ORTTON, Canada Southern Railroad—Mr. President, from the feeling here I do not see any actual necessity in changing the motion made by Mr. Johann, as it is just as he said this morning. As individuals we can use $3\frac{3}{4}$ or $3\frac{1}{2}$ inches; we are now simply expressing our opinion as Master Mechanics in regard to this subject. I am very favorably impressed with the $3\frac{3}{4}$ inch diameter, although I am now using $3\frac{1}{4}$ inches. If you put on a new $3\frac{3}{4}$ inch journal when it wears to $3\frac{1}{2}$ inches you will then have your standard; I see no necessity for changing the original motion of Mr. Johann.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. Presi-

dent, I understood Mr. Johann to say something in reference to the length; I would like to ask him if the Master Car Builders' Standard is six feet eleven inches?

Mr. JOHANN, Wabash Railroad—Mr. President, my motion is to adopt the Master Car Builders' Standard, or accept the Master Car Builders' Standard, which is six feet eleven and a quarter inches, as the choice of this Association.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I was mistaken then; I thought I understood you to say six feet eleven inches.

THE PRESIDENT—Gentlemen, are you ready for the question?

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, I made a motion to make it $3\frac{1}{2}$ instead of $3\frac{3}{4}$ inches.

THE PRESIDENT—Mr. Black, there was no second to your motion. The question now is upon the original motion of Mr. Johann, which is that this Association recommend the adoption of the Master Car Builders' Standard. All that are in favor of the recommendation for the adoption of the Master Car Builders' Standard Axle will please say aye, and the contrary no.

THE PRESIDENT—The yeas have it.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I call for the yeas and nays.

THE PRESIDENT—I will call for a standing vote, although I do not think there is any necessity for it. The Secretary will please count.

THE SECRETARY—Twenty-eight members for the adoption and nine against.

THE PRESIDENT—Mr. Johann's motion is carried.

Mr. JOHANN, Wabash Railroad—Gentlemen, I am very glad indeed we have disposed of this question, and I hope all the members will go home and do all they can towards introducing the standard axle.

THE PRESIDENT—Gentlemen, the next business in order is the reading of the report of your Committee upon the Best Material, Method, Form, and Proportion of Constructing Locomotive Boilers, and the Best Method of Economy in the Use of Fuel. The report will be read by the Chairman, Mr. Wells.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I wish to make a few excuses to the members of the Association for the length of the report. The reports from the members came in very late. Two or three of them were received only four or five days before I started to the Convention. The last communication that I received was from Howard Fry, and one that we had been waiting for, and when it arrived I had only three days to make out my report. Therefore, before printing this, I desire some portions of it to be condensed by the Secretary or the Committee. With these explanations I hope the members will indulge the Committee if we are a little lengthy on some points.

Mr. Wells then read the following report, giving various explanations on the blackboard:

Report of Committee on Boilers.

To the American Railway Master Mechanics' Association:

GENTLEMEN—At your last Convention, held in Richmond, Va., May 14th, 15th, and 16th, 1878, the Committee on Boilers was continued, and requested to make further investigation in reference to the best material for locomotive boilers, the best method of construction, and the best form and proportions for any specified service, and any kindred matters that might seem of sufficient importance to them bring to the notice of the Association.

Many or all of the different branches of this subject have been presented in the reports heretofore made to the Annual Conventions, and in them, and in the discussions which followed, they were so fully explained that your Committee find it difficult to present to your notice new facts on the subjects assigned us for investigation.

We issued a circular setting forth some of the points upon which we desired information and the opinion of those addressed. Our first question was as follows:

"It is important to know what is the best material for the several parts of locomotive boilers (state the kind of fuel used); whether iron is more liable to corrosion than steel; which of the two is more liable to furrow at seams, corners, braces, and at the top of the mud ring, and to 'pit' in the bottom of the cylinder part of the boiler on the water side of the sheets? It is also desirable to know the cause of this pitting and the remedy."

In answer to these inquiries we have received conflicting reports as to the best material for the shell of the boiler. On this part of our subject Mr. S. J. Hayes, Superintendent of Motive Power of the Illinois Central Railroad, who is one of the members of your Committee, makes the following report:

ILLINOIS CENTRAL RAILROAD.

[Machinery Department.]

CHICAGO, May 3, 1879.

R. WELLS, Esq., Chairman Committee on Boilers,
American Railway Master Mechanics' Association:

DEAR SIR—By reason of the pressing requirements of my regu-

lar duties I have been able to give but little thought to the subj
of your circular, and in replying to it at this late date am only a
to give an outline of my recent experience with boilers on this ro

"THE BEST MATERIAL FOR THE SEVERAL PARTS OF LOCOMOTI
BOILERS."

This subject having been so thoroughly canvassed in former r
ports leaves me but little new ground to work upon, and allowa
must be made if some of the ideas advanced should be found
former reports.

In my opinion a good quality of iron is preferable to steel for t
cylinder part of boilers. In former reports I have recommended t
use of steel for the entire boiler, but recent experience has led r
to believe that steel is not so well adapted for the cylinder part of t
boiler as a good quality of iron.

There are several engines now in service on this road with boil
built in 1856, the outside shells of which were made of Low M
iron. These boilers have been in service twenty-three years, a
there is but little sign of corrosion or pitting in the sheets. T
sheets in the bottom of the cylinder part of these boilers ha
never been renewed, and at present are to all appearances in go
condition.

In 1874 we built two new boilers, the shell of one of these boi
ers was made of a high grade of steel, the other of iron. Bo
engines were put in the same service, on the same section of t
road, and made equal mileage. When the flues were removed t
steel boiler was found to have suffered the most from corrosion, a
was pitted to such an extent that it was found necessary to p
lining plates on the inside, along the bottom of the cylinder part, t
protect it from further corrosion. The shell of the iron boiler w
somewhat corroded, but not nearly so much as the steel one.

Another boiler built in 1876, of "open hearth" steel, after runni
73,166 miles on a section of the line where the water is not consider
bad, was found to have been pitted and corroded in the bottom of t
cylinder part. At one place near the first seam, back of front fl
sheet, a furrow nine inches long and varying from $\frac{1}{32}$ to $\frac{1}{16}$ of an inc
in depth had been formed during the short time the boiler was i
service. At another place, close to the front flue sheet and directl

pletely around the engine house in a line directly over the back domes of the engines as they stand on the pits, and provided with a stop valve at each pit; this pipe has direct connection with a large steam pump which supplies a heavy pressure of water.

Each engine is provided with a crown wash-pipe and an attachment for washing bottom of cylinder part of boiler. These devices are both shown enlarged on the drawing.

On the arrival of an engine after making a trip, connection is made with a steam hose from the valve in-pipe overhead to a globe valve on the back dome, and steam drawn from the boiler is conveyed to a large supply water tank. The temperature of the water remaining in the boiler is lowered gradually by introducing a stream of cold water, and the boiler is cooled evenly and without being subjected to the strain of unequal contraction.

After the boiler has become cold the water is drawn off, connection being made between the pipe overhead and the crown-sheet wash pipe. A powerful stream is thrown in jets over the crown sheet, which quickly and thoroughly removes any incrustation which may have formed there during the trip. When the crown sheet has been cleaned the hose is attached to the shell wash-pipe, and the accumulation of mud and scale in the bottom of the cylinder part of boiler thoroughly washed out. This operation is repeated every round trip, and the result is that the boilers are kept comparatively clean, the crown sheets absolutely so.

A water pressure, varying from seventy to one hundred pounds per square inch, is found necessary to dislodge the incrustation and remove it from the boiler.

Since this system of washing out has been in operation a noticeable reduction in the expense of boiler repairs has been effected.

A device designed to purify the feed water has been applied to some of the locomotives on this road. In applying it to an engine in service the forward dome is loosely filled to the ring with scrap iron, supported on a grating placed at the bottom of the dome; this iron is heated to a high temperature by the steam, which circulates freely through the spaces between the variously shaped pieces.

The feed water instead of being introduced at the usual place on the side of the boiler, near the front flue sheet, and below the water level, enters the boiler and is delivered in a spray, or in thin sheets,

in the steam space near the top of the dome, and falls directly on the highly heated pieces of metal with which the dome is filled. In trickling through and among these pieces of metal the lime-salts and other impurities held in solution are precipitated and adhere to the scrap, the water passing on through into the boiler in a comparatively pure condition. The device has been patented in this country and in Europe.

The scale deposited in the dome is removed at intervals of about one month (this, however, depending on the nature of the service in which the engine is employed and the quality of the water), by taking off the dome cap, removing the incrusted scrap by hand, and scraping out the dome, which is then refilled with clean scrap or any other suitable substance to which the deposits will adhere.

The average quantity of scale removed from the dome of an engine thus equipped, per one thousand miles run on the Chicago division of this road, is forty pounds, and I estimate that an equal quantity of mud in addition to the amount ordinarily removed by washing is washed out of the boiler during the same time, making a total amount of eighty pounds of impurities removed per one thousand miles run by the use of this device.

It is noticeable that when this arrangement is applied to a boiler a much greater quantity of mud is washed out than when the engine was running without it. This effect is the result of retaining the mineral impurities in the dome. The particles of earthy matter which pass through the dome do not harden or form scale by themselves; and, when separated from the mineral impurities as they are by this device, settle freely at the bottom of the cylinder part and leg of the boiler, from which places they are easily removed by washing.

At places on the line where there are no facilities for properly washing out boilers, and where the scale is allowed to accumulate until it becomes necessary to remove the flues for the purpose of cleaning the boiler, the sheets in the bottom of the cylinder part of the boilers rapidly waste away. To protect these sheets against corrosion, and the wear resulting from the movement back and forth, from the motion of the water in the boiler, of the impurities which settle on them, I have had lining plates of common iron, about $\frac{3}{16}$ of an inch in thickness and thirty-six inches in width, fitted to the bottom of the shell and secured in position by $\frac{5}{8}$ inch rivets placed

twelve inches apart. These plates form no part of the structure of the boiler, but simply act as a protection to the sheets. Care is taken to have the edges of the plates fitted closely to the sheets of the boiler, and as an additional protection a heavy coating of mineral paint is put on the inside of the shell, under the plates, before they are secured in position. Very good results have been obtained from their use.

The wear and corrosion acts on the plates instead of the sheets of the boiler. Several of our engines lined in this manner have been running two years, and show no perceptible signs of pitting or furrowing of the sheets under the plates. The corners of the throat sheets, which are subjected to severe wear, have also been successfully protected in this manner.

This plan of lining those parts of the shell exposed to the greatest wear has not yet been tried long enough to fully demonstrate its value; but, from the experience we have had, I am satisfied it affords great protection to the sheets, and have had liners put in several new boilers recently built.

Respectfully,

S. J. HAYES, Sup't Machinery.

On this subject your Committee present also the opinions of Mr. James M. Boone, Master Mechanic of the Western Division of the Pittsburgh, Ft. Wayne & Chicago Railroad.

Mr. Boone says, " In answer to your circular would say:

" 1st. I continue of the opinion that steel is the best material for boilers, with either wood or coal as fuel. I find iron to be more liable to corrosion than steel. Our first steel boilers were built in 1871; have never found any corrosion, furrows, or pitting inside of them. Iron boilers of the same size, same service, and using the same water have corroded on the inside in six years' service so bad that sheets had to be cut out and replaced with new. I believe this pitting is produced by both mechanical and chemical action. The expansion and contraction of the sheets of iron open the fiber, water enters, and pitting ensues. Steel being more homogeneous than iron, this action does not so readily take place. The only action of this kind we have had on our steel boilers is at the inside corners of the fire box, at the mud ring. We have had less trouble here with our

steel than with iron boilers. To overcome this, I believe it would be an advantage to have the lower ends of the fire-box sheets rolled thicker to about the level of the fire. The bottom of the fire box would last longer by so doing. There is a possibility, however, that the danger from sheets cracking would be increased by this increase of thickness."

Still further, in regard to the best material for boilers, Mr. Sedgley, of the Lake Shore & Michigan Southern Railway, says: "We prefer steel for boilers, and find it much less liable to furrow, pit, and corrode than iron; the pitting we attribute to the chemical action of the impurities in the water."

Mr. William Fuller, General Master Mechanic of the Atlantic & Gt. Western Railroad, in reference to this subject, says: "With the experience which the Atlantic & Gt. Western Railroad has had with various kinds of metals for locomotive boilers and fire boxes, we prefer a first-class homogeneous steel for outside shell, fire box, and cylinder part of the boiler. On some portions of our road, where we are compelled to use lime water, we have found it necessary to use iron for crown sheets in place of steel, which we found by our experience burned out and cracked from crown rivets much worse than iron sheets. We seem to have less trouble with steel boilers, on account of pitting and furrowing, than we did with iron; yet we are not altogether free from furrowing by the use of steel. We have had considerable trouble with our steel fire boxes furrowing on top of mud ring, especially when we use water impregnated with lime. We also have considerable trouble with fire boxes being eaten away in the lower back corners on the fire side of the sheet. Thus far we have not had any trouble with our steel boilers furrowing at seams and bottom of cylinder part of boiler. We use bituminous block coal exclusively for fuel. The cause of boilers pitting and furrowing is no doubt due very much to the impurities in the water. Our boilers made of iron pit and furrow much more with the lime water than they do with water free from lime."

From the reports made to us we find that there still exists a difference of opinion as to the best material for the shell, and some other parts of the boiler, in the minds of some who have had a large experience in the care of locomotives. Steel is evidently taking the place of iron for boilers to a greater extent than ever before. The

improvements in machinery for manufacturing steel, and the care and skill exercised in determining its chemical proportions, enables manufacturers to produce steel suitable for almost any service that may be required of it.

There are, perhaps, localities where, on account of certain impurities in the water used, iron may answer a better purpose than steel, yet that fact is not prominently brought out. The localities where that seems to be the case are not numerous or extensive. Pitting, as it is called, occurs at unlooked for places; that is, it takes place where there is no apparent cause for it, while furrowing at seams, curves, and where braces are attached, can easily be accounted for. The cause of pitting is not satisfactorily explained. We know that it occurs, and that on some roads it is a serious difficulty, while on others it is scarcely known. Our investigations so far have failed to determine the particular cause or a remedy.

Our second question was as follows:

"The best methods of constructing locomotive boilers as to strength, tightness of seams, durability, size of rivets and spaces between them; drilled holes compared with punched holes; the best plan of supporting the crown sheet; strengthening the shell of the boiler at the base of the dome; bracing the ends. Whether or not it is essential to anneal all flanged sheets after flanging; the best arrangement for cleaning mud and scale from the barrel of the boiler and the crown sheet; any other matters, regarded as an improvement over the common practice, in the construction and arrangement of locomotive boilers."

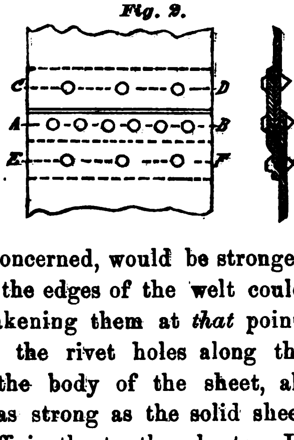
In answer to the part of our subject refered to in this question, we have been unable to obtain much information that has not been heretofore presented in our reports. We find that more care and attention is given to details in the construction of boilers than formerly, insuring greater safety and durability. The 'welt' at all longitudinal seams is being adopted by nearly all builders. The different forms of 'welt' seam used by a number of different roads was illustrated in the Eleventh Annual Report.

The plan of welt seam most generally adopted is similar to that shown in Figure 2. We may safely say that a riveted seam can not be made as strong as the body of the sheet. It is of interest to know, however, how near in practice we can approach the strength

of the sheet by a welt at the seam. The rivet holes in a sheet, on any one line, weaken it to the extent of the metal removed in making the holes. Then, if a welt be extended from the single row of rivets at the edge of the seam out into the body of the sheet, and a line of rivets connect the edge of the welt with the body of the sheet along C D and E F, the sheet itself will be weakened at *that* point to the extent of the metal lost by making the holes; and although the metal at the seam, along A B by reason of the welt, is sufficient to make it as strong at that point as the body of the sheet, yet the sheet is weakened through C D and E F by the rivet holes necessary to fasten the welt to the sheet.

Theoretically and practically we may say that a well-proportioned welt seam, of a form shown in Fig. 2, can not have a strength greater than about 80 per cent. of that of the body of the sheet; for this reason we will assume that the sheets and welt are $\frac{3}{8}$ of an inch thick, and the rivet holes are $\frac{13}{16}$ of an inch in diameter, and that they are 2 inches between centers, along the line A B, there would then be $1\frac{3}{16}$ inches of metal between the holes in the sheet and the same in the welt, and the seam at that point, so far as metal is concerned, would be stronger than the body of the sheet, provided the edges of the welt could be fastened to the sheets without weakening them at *that* point. Now, as there is more metal between the rivet holes along the line A B, than on a similar line in the body of the sheet, all that is required to make the seam as strong as the solid sheet is to secure the edges of the welt sufficiently to the sheets. In securing these edges, however, the body of the sheet is weakened through the lines C D and E F, to the extent of the metal removed in making the holes. Along the line A B 40.62 per cent. of the metal is taken away by the holes, leaving 59.38 per cent.; but the welt adds an equal per cent. of metal, making 18.76 per cent. more metal between the holes on that line than through the solid sheet. Without fastening the edges of the welt to the sheets this seam would, however, be but 59.38 per cent. of the strength of

Fig. 2.



the solid sheet. The question is then, how much can be added to the strength of this seam by fastening the edges of this welt, along C D and E F, to the sheets? To make it full strength 40.62 per cent. should be added. If the rivet holes along the lines C D and E F be placed four inches between centers, then 20.31 per cent. of the metal along those lines will be removed, and the sheets weakened to that extent. Now, by placing rivets in these holes, securing the welts to the sheets along those lines, the seam along the line A B will be strengthened to the extent of the strength of the rivets in the line C D or in E F. As these rivets have a sectional area of 20.31 per cent. of the solid sheet, then at least that much will be added to the strength through the line A B, making a total for the welt seam of 79.69 per cent. of the strength of the solid sheet; the difference being 20.31 per cent., or precisely the per cent. of metal removed for the holes along C D E F. We may, therefore, conclude that the limit of strength attainable with a welt seam of that form is in round numbers 80 per cent. of that of the solid sheet, and that this is, perhaps, the best form of welt seam, or as good as any, applicable to the locomotive boiler. The size of rivets and spaces between centers will, of course, depend on the thickness of sheets used. The proportions given above are for $\frac{3}{8}$ inch steel sheets.

In regard to the best method of constructing locomotive boilers as to strength, tightness, durability, etc., we have nothing radically new to report.

Your Committee recommend, and believe it very necessary, to anneal all sheets which are put into fire boxes, and all flanged sheets in other parts of the boiler; by so doing the unnatural strains left in the sheets by flanging and working will be relieved.

Mr. Sedgley, of the Lake Shore & Michigan Southern Railroad, in reference to this subject says: "In regard to construction, size of rivets, etc., our practice is to use $\frac{11}{16}$ inch rivets in $\frac{3}{8}$ inch plates, and welt all longitudinal seams and cross seams below the water line. We find but little difference whether the holes be drilled or punched if the sheets are afterward annealed.

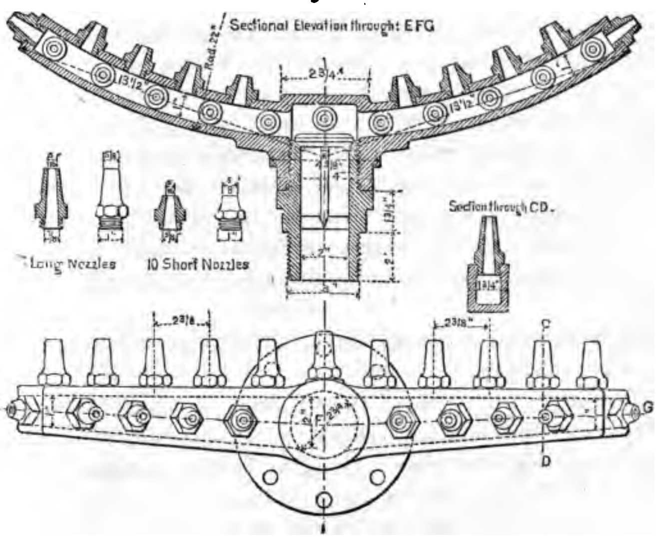
"We arrange the ends of the crown bars to rest upon the side sheets, using a washer $1\frac{1}{2}$ inches high between crown bar and crown sheet, with small bearing on the latter. We also use a requisite number of stays between crown bar and outside of shell of boiler.

For cleaning mud and scale from boilers, we use a cock in the bottom of the cylinder part of the boiler near the front tube sheet, attaching hose for washing that part of the boiler, and washing the fire box in the usual manner."

Mr. Jacob Johann, of the Wabash Railroad, has designed and put in use in the boilers of several engines on that road, an arrangement for washing the mud and scale from the bottom of the cylinder part of the boiler, shown in Fig. 3.

Wabash Railway, Western Division—Standard Boiler Washer.

Fig. 3.



This arrangement, consisting of a curved pipe, with a series of nozzles projecting from the side and top of the pipe, is placed on the inside of the cylinder part of the boiler at the bottom, and as close as practicable to the front tube sheet. This pipe is attached to the bottom of the boiler, a part of it projecting out, to which, when the boiler is to be cleaned out, a hose or pipe is attached by a nut; water is then forced into the boiler through this pipe, and the series of small nozzles arranged on the top and on the side towards the back end of the boiler, at a pressure of from 50 to 100 pounds to the square inch, which dislodges the scale and mud that may have settled

on the bottom of the boiler or between the tubes in the vicinity of the vertical nozzles, washing it back to the leg of the boiler at the fire box, where it is readily removed through the hand-holes. The check valve shown at H, closes the opening at the base of the pipe at all times except when water is being forced into the boiler when washing out.

This arrangement seems to be one that will answer a good purpose, provided the scale does not form on the inside of the pipe and small nozzles, as it does on the heating surfaces, and in time close them up. Access to these parts can only be had when the tubes are removed from the boiler.

Mr. Fuller, of the Atlantic & Gt. Western Railroad, in alluding to the removal of scale and mud from boilers, says: "Our only successful way of removing scale and mud from crown sheet and cylinder part of boilers, is to remove crown bars and flues. We have obtained very good results from a blow-off cock, placed underneath at forward end of cylinder part of boiler, with a pipe running back into the ash pan, with levers from the cab to work it when the engines are running; this being used frequently while in service has operated quite successfully in keeping mud from the cylinder part of boiler."

The third question presented in our Circular soliciting information, was as follows:

"It is important to know the best form of boiler, all things considered, for the different classes of locomotives, as between the 'wagon top' and the plain 'straight' boiler; a single or double dome; the best point for the dome or domes; the cylinder part with a taper due to the thickness of the sheets of the different rings, or a taper considerably greater than that. The best form of fire box, and form of sheets composing it; whether corrugations or channels in steel and iron side and back sheets of the fire-box, extending from the mud ring vertically to, say, thirty inches above the grate, are a preventative against rupture of such sheets, and of leakage at the stay bolts in the lower part of the fire box; and if so, the best form of such corrugations. Which the best, the 'plain fire box,' the 'water table,' or 'brick arch,' as regards evaporation? The best thickness for the several sheets of the fire box and for the tubes."

Mr. Sedgley, of the Lake Shore & Michigan Southern Railroad, in reply to this question, says: "We prefer a taper of from three to

four inches in the length of the cylinder of the boiler without wagon top. Single dome, on first sheet forward of fire box. To strengthen the dome we flange the sheet on which the dome rests upward and outwardly, sufficiently to receive a row of rivets through the straight part of the dome in addition to the usual row of rivets through the flange of the dome. For fire box we prefer sheets $\frac{5}{16}$ of an inch thick, except tube sheets $\frac{7}{16}$ of an inch in thickness. Side sheets, corrugated or waved, about $\frac{1}{2}$ inch, extending from mud ring upward about three feet. We find this form of corrugation a thorough preventative against rupture of plates, and also against leaky stay bolts, if the latter are properly put in. We prefer plain fire boxes without water table or brick arches. We use No. 12 wire gauge tubes."

Mr. Wilson Eddy, Master Mechanic of the Boston & Albany Railroad, says in reference to the best form of boilers: "I put no domes on my boilers, and am making the cylinder part of two plates only, putting the front sheet outside, so that the front end is the largest. I am opposed to the usual method of telescoping boilers because I like the space for water. Give me space for water and fire and I will risk the steam room, especially if I have the perforated steam pipe properly constructed."

Mr. Eddy's plan of tapering a boiler is the reverse of that generally adopted. Your Committee consider Mr. Sedgley's plan, in the case of the ordinary American style of eight-wheel locomotive, to be much the best of the two, for the reason that the same quantity of water can be carried in a boiler regardless of the direction of the taper, other things being equal; and when the forward end is smallest it will be lightest, consequently less dead weight will be carried by the truck, and a proportionately greater weight be carried on the drivers.

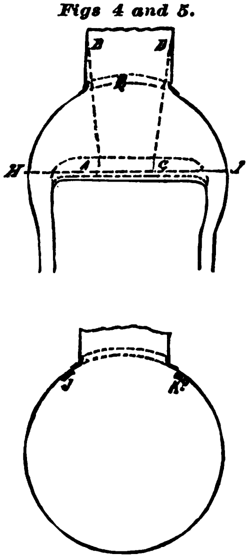
Mr. George Coolidge, Superintendent Motive Power of the Fitchburg Railroad Company, says that he gets no better results in the use of the wagon-top pattern of boiler than with the straight pattern, and considers the latter the stronger form and preferable.

The "straight boiler," as it is called, with a taper due only to the thickness of the sheets forming the shell, is being more extensively used than formerly; and, in the opinion of your Committee, for ordinary cases is the cheapest, strongest, most durable, and best form when made of sufficient diameter to afford the necessary steam room

Some contend that a dome is a useless appendage to a boiler, and ought to be dispensed with, yet no convincing reasons are given to show why the dome is useless. One objection urged is, that the dome-hole weakens the boiler. It is necessary, however, to have access to the interior of the boiler, and there is no reason why the dome in its attachment to the boiler can not be made as strong as a man-hole. The top of the dome affords a convenient location for the safety valves and the whistle, and the interior a suitable place for locating the throttle valve, which, in case of a boiler having no dome, would require some special arrangement that, on the whole, would be as objectionable and expensive as a dome.

The best point for locating the dome, so far as strength is concerned, is over the fire box. The dome-hole at that point weakens the shell less than at a point on cylinder part, for the reason that the braces extending from the crown bars to the dome, strengthen the shell in one direction, and the top stay bolts or braces, extending across the boiler above the crown sheet, strengthen it, or rather relieve it of part of the strain, due to a circular form, in the other direction. Let Figs. 4 and 5 illustrate.

Figs 4 and 5.



In the case of a dome over the fire box, Fig. 4, the shell at the dome-hole is strengthened by the braces A B and and C D against the internal pressure in that direction, while the tensile strain on the section of boiler through E is relieved of one-half of the strain, due to a form represented in Fig. 5, for the reason that the top stay bolts and the transverse braces above the crown sheet, in the direction of H I, bear the strain below that point.

In the case of a dome on the cylinder part of the boiler, as represented in Fig. 5, there can be no braces, except a ring be placed on the inside and riveted to the shell at J K, which would be a good plan and ample in strength if well proportioned.

The plain rectangular form of fire box, without water leg or brick arch, is still very generally used on

nearly all the roads in this country. Some roads, however, have their passenger engines equipped with the brick arch; and a few, mostly in the Eastern States, use it in their freight engines. Some roads, after testing the brick arch for several years, have abandoned its use, owing mainly to the difficulty experienced from the side sheets of the fire box cracking at or near the back end of the brick arch.

The Chicago & North Western, Lake Shore & Michigan Southern, and several other roads have a large number of fire boxes in use with the waved or corrugated side sheets. The Jeffersonville, Madison & Indianapolis Railroad have about twenty-five fire boxes in use, with vertical channels $\frac{3}{8}$ of an inch deep between the alternate rows of stay bolts, extending from the mud ring to about thirty inches above the grate. Some of these fire boxes have been in use over three years, and the side sheets are free from cracks or "checks" at stay bolts, and no leakage of stay bolts nearest the fire has ever occurred. These channels or corrugations seem to be an absolute preventative against rupture of the sheets.

Mr. Sedgley makes the same statement in regard to his experience with the waved side sheets in use in the boilers on his road.

Mr. Charles Graham, of the Lackawanna & Bloomsburg Railroad, and Mr. Tilton of the Chicago & North Western Railroad, give equally flattering accounts of the durability of the waved sheets in fire boxes of boilers in service on their roads.

The causes which operate to produce rupture in fire-box sheets and the remedy, were fully explained and pointed out in our report to the Tenth Annual Convention.

The thickness adopted for the several sheets of the fire box seems to be almost universally the same on all roads. They are for side and door sheets $\frac{5}{16}$ of an inch, for crown sheets $\frac{5}{16}$ and $\frac{3}{8}$ of an inch, and for flue sheets $\frac{7}{16}$ of an inch thick.

Your Committee would call the attention of the members of the Association to a new form of boiler, designed and tested by Mr. Stefan Verderber, Inspector-in-chief of the Hungarian State Railways, a full description and drawings of which was published in the Railroad Gazette, February 28th, 1879. In Mr. Verdeber's plan the fire box as a steam generator is dispensed with. The fire box is an iron shell lined with fire brick; the heated gases imparting their

heat to the water while passing through the tubes. His tests with a locomotive, continued for a number of weeks drawing freight trains, when compared with the results shown by another locomotive of similar proportions, having the ordinary fire box and run on the same line, under the same circumstances, show that he obtained as good results in evaporation with the boiler which had no water spaces around the fire box as with the one that had. This, according to the popular opinion, would seem to be paradoxical. Heretofore the belief has generally prevailed that a reduction in heating surface would result in a reduction of the quantity of water evaporated to the pound of coal.

In Mr. Verderber's published statement are a few matters to be considered, before concluding that the common practice is to give way to something better and more economical in this form of boiler:

1st. It is stated that at the first trials considerable difficulty was experienced from leakage of the tubes and the bulging of the tube sheet. This was, however, afterwards overcome by changing the boiler so as to allow the tube sheet and cylinder part of the boiler to extend back about a foot into the fire box.

2d. For equal consumption of fuel, per hour, it was found necessary to reduce the nozzles of the exhaust pipes to a considerable extent below that when the ordinary fire box was used.

3d. The quantity of water in the boiler was very much reduced, causing the water level to fall much more quickly, and requiring closer attention in supplying the requisite quantity of feed water than in the case of the boiler with the water-space fire box.

4th. The settling of the solid ingredients contained in the water, having less space in which to settle, the boiler required more frequent cleaning out.

5th. The quantity of water evaporated to coal consumed by this boiler was an average of 4.55 pounds of water to 1 pound of coal, while in the case of the other locomotive of the same class and type, except the fire box, which was of the ordinary pattern with water spaces, the evaporation was 4.62 pounds of water to 1 pound of coal, being a slight increase.

The evaporation in the case of the Verdeber boiler as given above,

is a low average, and considerably below that of locomotive boilers of the usual form in this country.

If there is no advantage in evaporation to fuel consumed in favor of the Verderber boiler, it is very questionable whether it will prove to be more economical than the common boiler. A shell of boiler iron similar to that around the fire box is required to hold the brick lining, and the fire brick forming the lining will necessarily need renewing every few months, with the possibility of the lining burning out in the most exposed parts, at unexpected intervals, exposing the metal shell to injurious temperature, etc., are likely, in the aggregate, to give as much trouble and be as expensive as the common water-lined fire box now in use.

Our fourth question was follows :

"The best proportions for a boiler that will evaporate the greatest quantity of water to the pound of coal consumed as demonstrated in practice. State the style of engine, size of cylinders, of drivers, average speed of train; the weight of engine and train, water evaporated per hour, and per pound of coal, kind and quality of coal; the character of water as to the formation of scale. Give area of grate, length, width and height of fire box above the grate, area of fire-box heating surface (deducting for fire door and tube holes), area of tube surface (taking inside diameter), number, length, and diameter of tubes, kind of tubes, spaces between them; water spaces around the fire box, depth of water on crown sheet; weight of water in the boiler, in working condition; diameter of boiler at the middle of its length; 'straight' or 'wagon-top' pattern; thickness of fire-box sheets, and of tubes; area of hollow stays, if any, and where situated; single or double exhaust nozzle, and diameter of same; thickness of bars in the grate, and spaces between them. It is important to know the proportions, as above, of boilers evaporating the greatest quantity of water to the pound of coal, and your Committee will be glad to get the data as indicated in the case of locomotives giving the best results in evaporation, as a means of determining whether any change from the proportions of boiler, now in general use, can be made that would result in economy in the use of fuel. We earnestly solicit replies to the above."

In reply we have received communications from several Master Mechanics and Superintendents of Motive Power, which we present

with this report. That of Mr. Johann, of the Wabash Railroad, is as follows:

WABASH RAILROAD, WESTERN DIVISION.

REUBEN WELLS, ESQ.,
Chairman of Committee on Locomotive Boilers:

DEAR SIR—I propose to give in the following paper the results of a series of experiments made by me during the past year, to determine the economical superiority of a large, over a small, fire box and boiler, with the same cylinder capacity. Basing this superiority upon the tonnage per mile per pound of coal, instead of upon the miles run to the ton of coal, and the water evaporated per pound of coal, as has been the practice in nearly all experiments that have come under my observation.

Having but one class of engines on this division, namely, the ordinary "eight-wheeled or four-coupled" American engine, I am necessarily confined in my experiments to existing differences in this one class of engine; and, furthermore, as the majority of the boilers of these engines are of the "wagon-top form," and possess but little difference in their capacity, my field for experiment in this direction is exceedingly limited. The chief difference in the boilers of these engines, consists in some having an eight inch longer fire box, and consequently more steam and water capacity for the same dimension of cylinders.

For the purpose of experiment four engines were selected which were of the same make originally, and which were, as near as possible, in the same general condition as to running order at the time the experiments were made. Two of these engines are in passenger service and two in freight service; one in each service having an eight inch longer fire box than the remaining one. These engines were then fitted up with the necessary apparatus for conducting the experiments and placed in service over the same part of this division.

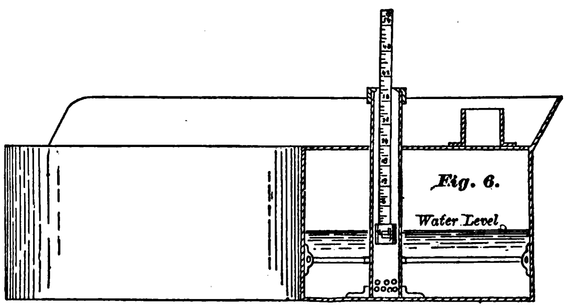
METHOD OF CONDUCTING THE EXPERIMENTS.

For ascertaining the actual amount of water consumed, a piece of six inch wrought iron pipe was inserted through the top of the tank and reaching to the bottom, just in front of the man-hole, and was then well braced to prevent vibration. The bottom of this pipe was

closed and a number of small holes drilled near the lower end, of just sufficient area to allow the water ready access to the inside of the pipe as rapidly as the water rose in the tank when filling. A small wooden float, with a stem graduated in inches, was allowed to play up and down in this pipe, with rise and fall of the water, and held in a vertical position by passing through a slotted hole in a sheet-iron cap or cover to the pipe. By this arrangement the wooden float was but slightly subject to the oscillations and "swashings" of the water in the tank, and indicated at any time the actual height of water. Care was taken to prevent the water in the tank from getting too low to buoy up the wooden float.

The accompanying sketch, Fig. 6, will show more clearly the method above described:

Longitudinal Section Through Tank.



Before starting out upon the experiment each tank was run upon the scale and weighed, an arbitrary number of inches of water were then allowed to run out, and the tank again weighed, from which was obtained the weight of one inch in height of water in each tank.

During the experiments the height of the water was noted, immediately upon the engine being coupled to the train, before and after each taking of water and upon being uncoupled from train, thereby obtaining the data from which the actual weight of water used during each trip was obtained.

WEIGHT OF THE COAL USED.

At the beginning and ending of each series of experiments

the coal in the tank was weighed; while on the road the weight in pounds as given at the coal chutes was assumed to be correct.

PYROMETER.

The pyrometer used during the experiments was kindly loaned by Prof. Chas. A. Smith, of Washington University, St. Louis, Mo., and is marked "Casartelli, Manchester;" it is graduated to show a temperature of 1,200°. It was projected as near as possible through the top of the smoke arch, about five inches in front of the flue sheet, and extended nearly to the bottom row of flues; by thus crossing all the horizontal rows of flue openings an average temperature of the gases passing through them, was more nearly obtained. On the passenger runs the reading of the pyrometer was noted every three minutes, and on the freight runs every four minutes, together with the position of the reverse lever.

In obtaining the average temperature during each trip, all readings obtained after shutting off steam were discarded, together with temperatures in starting out of stations, as it was noticed that the pointer rose rapidly when warming up and then gradually settled back.

TEMPERATURE OF FEED WATER.

The temperature of the water, as indicated by a thermometer placed in the tank, was noted at stated times during each trip, and an average temperature for each series was obtained from these.

WEIGHT OF PASSENGER TRAINS.

In estimating the weight of the passenger trains the numbers and classes of cars composing each train was noted, and from the official record the weight of these cars was obtained. The weight of the passenger load was obtained by counting the number on the train at different times during each trip, an average taken, and 130 pounds weight allowed for each passenger.

EXPERIMENTAL TRIPS WITH PASSENGER ENGINES 150 AND 144.

The experiments were made in August, 1878; both engines running at the same time and in the same service. Engine 144 was turned out of shop, after receiving general repairs, on April 13, 1878.

Engine 150, when taken into the shop the last time, was of the same dimensions as engine 144. The fire box and leg of boiler were then lengthened out eight inches, and the engine was turned out of the shop, after receiving general repairs, March 15th, 1878.

These engines were then started out on the experiment in the regular passenger runs, each engineer running his own engine. As the engines on this division are run "first in, first out," each engine made one or more trips with the same trains.

By reference to Table A, which contains the tabulated results of this series of experiments, it will be seen that engine 144, with the smaller fire box, shows trifling better results as to coal and water consumption, and tonnage per mile, than engine 150.

This may be accounted for, however, by the facts that the average train was heavier, and consequently the engine was working nearer its maximum capacity, and that the engineer used extra precautions during the trial, while the engineer of engine 150 ran as usual. This latter statement is borne out by the fact that in the "yearly performance" of the two engines for 1878, engine 150 made 35.06 miles to the ton of coal, while engine 144 made 33.65 miles, a difference of 1.41 miles to the ton of coal in favor of engine 150—the average train for the year on this run being six cars.

EXPERIMENTAL TRIPS WITH FREIGHT ENGINES 159 AND 171.

These experiments were made in March and April of 1878, both engines running over the same portions of the division, and as nearly as possible on through trains. Engine 159, with the smaller fire box, and engine 171, with the larger fire box, were both turned out of the shop, after receiving general repairs, in November, 1878.

From the experience in the previous experiment of running each engine with its regular engineer, I determined in this case to select a good average engineer and fireman, and allow them to run both engines, and in order to familiarize themselves with the engines, they were required to make two trips with each before any records were taken. This, of course, necessitated the running of the engines at different times, but the result proved the advisability of the change.

As will be seen by reference to Table A, engine 171, with the larger fire box, gave much the best results, averaging 3.27 miles

more to the ton of coal, nearly half a pound more water evaporated to the pound of coal, and 1.67 tons more tonnage per mile per pound of coal. This result is justified by the yearly performance of the two engines for 1878, engine 171 making 30.9 miles per ton of coal, and engine 159, 28.6 miles to the ton of coal, a difference of 2.3 miles per ton of coal in favor of engine 171.

As will be seen, this comparative yearly performance corresponds with that between engines 144 and 150, and is a further corroboration of the superior "jockeyism" exhibited by the engineer of engine 144 during the time of the experiment.

In determining the average train weight, when cars were only hauled a portion of the distance, the weight of the cars hauled such a distance was reduced to an equivalent weight hauled the entire distance of 113 miles, thereby obtaining in each case an average weight of train hauled 113 miles.

EXPERIMENTAL TRIPS WITH PASSENGER ENGINE 144, WITH CLOSED AND HOLLOW STAY BOLTS.

The class of engines to which the 144 belongs came on this road fitted up with two rows of hollow stay bolts around the fire box.

In the winter of 1876–'7, the engineer of engine 144 made serious complaint as to the difficulty in obtaining sufficient steam, and attributed this difficulty to the hollow stay bolts. I then had them plugged up with red lead, with a marked improvement in the engine's steaming qualities. The hollow stays on other engines of the same class were filled in the same manner, and with the same result, and I then discontinued the use of hollow stays.

In order to justify myself for this discontinuance, I made a series of trips in March, 1879,—one series with the stay bolts still closed, and another with the stay bolts opened out.

These stays were eighty in number, with $\frac{7}{16}$ inch openings, arranged with 18 in the front and back, and 22 on each side of the fire box. The height of the first row above the top of the grate being 11 inches, and the distance between the rows 4 inches. The total area of the openings being 12.027 square inches.

The results of these experiments are also given in Table A. The evaporation of water to the pound of coal is a trifle better with the open than with the closed stay bolts, yet the average tonnage is nearly eight-tenths of a ton per mile per pound of coal less.

PYROMETER EXPERIMENTS FOR ASCERTAINING THE AVERAGE TEMPERATURE OF THE GASES IN THE SMOKE BOX.

At the time of making the open and closed stay-bolt trips, the temperature of the smoke-box gases was also noted.

By a reference to Table A, which contains the results, it will be seen that the average temperature of the escaping gases was greater with the closed than with the open stays, but at the same time the tonnage per mile was proportionally much greater.

This experiment shows also the effect of an increased speed in increasing the average temperature of the gases, the rate of speed of train 6 being 19.26 miles, and of train 3, 34.77 miles per hour, the average temperature of gases in both cases being greater for train 3 than for train 6.

While standing still, the temperature of the gases varied from 375° to 400°, and while going into stations after shutting off steam, from 500° to 550°. On opening the fire door for the purpose of "coaling up," the temperature dropped from 50° to 75°.

The number of seconds required for the smoke to clear away from the stack was also noted at various times and under various circumstances, the timing beginning immediately after closing the fire door on the last shovel full of coal. With the closed stays it required on the average 41 seconds, and with the open stays 38 seconds, for the smoke to disappear.

On Table A will also be found the results of the pyrometer tests with the two freight engines 159 and 171. The average temperature of engine 171, with the large fire box, is much greater than with engine 159. But again it will be noticed the engine showing the highest average temperature has also much the largest average tonnage per mile.

In this experiment it was observed that when the engine was working hard and moving slow, with the lever full forward, the highest temperatures were obtained; but if the lever was moved back slowly as the speed increased, the temperature fell but little. The length of the blasts being shortened, but their rapidity increased.

The ruling grades over which the engines run are given in Table A. An analysis of the coals used, which were of a kind known as Illinois block coal, show the average to have been as follows: Calo-

rific power, 6,555°; calorific intensity, 2,586°; calorific power as compared with carbon as 100 to 81.36.

From the results obtained from these experiments I arrive at the conclusion that the boiler with the largest capacity to any given size cylinder is the most efficient and economical. And while aware that under certain conditions the smaller boiler shows an equally good performance, yet when loaded to the fullest capacity of the cylinder power, the larger boiler will invariably appear to better advantage in economy and work performed.

In reference to the escape of gases at very high temperatures from the stack, there is no remedy as long as we use the exhaust nozzles to create a blast. The proper remedy can only be obtained by increasing the grate area and heating surface, to allow the gases a longer time for complete combustion in the fire bed, and thereby be enabled to enlarge the exhaust nozzles, thus preventing the violent lifting of the fire and expulsion of the gases before the heat is extracted by the water. Under the present condition of things this is hardly attainable for want of sufficient space.

The results of the experiments with hollow or open stay bolts as compared with solid or closed stay bolts, indicate an advantage in favor of the solid stays. Although in the case of the hollow stays there was not so much smoke, nor was the temperature of the escaping gases so high, as in the case of the closed stays, but there was a decided economy in work done in favor of the latter.

From my observations, not only from these experiments, but from the general work done on this division by engines of the same capacity with both kinds of stay bolts, I am satisfied there is no economical advantage whatever in the use of hollow stays as long as sufficient air can enter through the grate and pass through the fire bed.

Very truly, yours,

JACOB JOHANN, M. M.

Mr. Fuller, of the Atlantic & Great Western Railroad, gives the dimensions of a passenger engine of the ordinary eight-wheel pattern, and the results of a test made with the same on that road, which are set forth in Table A. The boiler is of the wagon-top pattern, having hollow stays on the side and back of the fire box, 12 inches above the grate, the area of the holes aggregating 3.33 square inches.

In regard to proportions and work done per pound of coal consumed, Mr. Sedgley, of the Lake Shore & Michigan Southern Railroad, makes the following statement:

"In regard to performance of engines, etc., I enclose you a statement showing performance of 7 Baldwin Moguls and 7 eight-wheel engines on our road last year. The Moguls have straight boilers, with dome on sheet forward of fire-box; 148 two-inch tubes, 11 feet 2 inches long, with fire box 5 feet long and 5 feet deep, 35 inches wide, and heating surface, 846 feet, inside measure; 16 by 24 inch cylinders, and $4\frac{1}{2}$-feet wheels. The eight-wheel engines have wagon-top boiler, dome over fire box, the latter 5 feet 5 inches long, and 5 feet 3 inches deep, and 35 inches wide; 155 two-inch tubes, 11 feet 1 inch long; heating surface, 893 feet, inside measure; 17 by 24 inch cylinders; 5-feet wheels. Both engines were in similar condition, service, etc., and it would seem to be a very fair test.

"The 7 Mogul engines made a total mileage of 228,057 miles, with an average load of 41.95 loaded cars per train mile, and a consumption of 1.73 pounds of coal per car. The 7 eight-wheel engines made a total mileage of 221,100 miles, the average load being 41.24 cars per train, and consumption of coal, 1.77 pounds per car per mile."

From this report it seems that the 7 Mogul engines, with the straight boiler and a heating surface of 846 feet, did 2.20 per cent. more work to the pound of coal than the eight-wheel engines with wagon-top boiler and 5.25 per cent. more heating surface. The work done by all these engines to the pound of coal is remarkably good.

Mr. James M. Boone, of the Pittsburg, Ft. Wayne & Chicago Railroad, in giving the results of a test of one of his boilers, says:

"This engine is the ordinary American engine, with cylinders 16 by 24 inches; drivers, 66 inches; weight of engine, 73,000 pounds; weight on drivers, 46,700 pounds; coal used was bituminous, of a fair quality, known as State-line coal; the water is bad, forming scale very rapidly; grate area, 15 square feet; fire box, 60 inches long and 36 inches wide. At front end, fire box is $55\frac{1}{2}$ inches high; at back end, $50\frac{1}{2}$ inches high above grates, crown sheet being on an angle. Heating surface of fire box, 86.1 square feet; area of tube surface, 745 square feet; tubes, 149, 11 feet long, $1\frac{3}{4}$ inches inside diameter; iron; space between them, $\frac{7}{8}$ inch back and $\frac{15}{16}$ inch

front end; front of fire box, 4-inch water space, sides and back end, $3\frac{1}{2}$ inches. With two gauges of water; 6 inches depth of water front end of crown sheet, and 11 inches on back end. With two gauges; the weight of water in boiler is 6,550 pounds in working condition. The boiler is $48\frac{3}{4}$ inches in diameter in middle of its length; wagon top, 10 inches above straight part; crown sheet, $\frac{5}{16}$ inch; side sheet, $\frac{1}{4}$ inch; tube sheet, $\frac{7}{16}$ inch; tubes, No. 10, gauge thickness; 58 hollow stays, the first row, 7 inches above grate, next row, 11 inches above grate; area of opening in hollow stays, 6.4 square inches; double exhaust nozzles, diameter of opening of each, 3 inches; bars in grate, $\frac{7}{8}$ inch thick, with $\frac{3}{4}$ inch opening between them. The above described boiler is a good steamer; will make steam freely with nut coal; does the best work with about 4 inches of coal on the grate."

The proportions of this engine and the results of the test are set forth in Table A, and show very good results in work done for fuel consumed.

On the question of "best proportions," we find that the practice with English locomotive builders is to use more tubes and of a smaller diameter than is the practice in this country. On this subject Mr. Edward H. Williams, of the Baldwin Locomotive Works, who has observed carefully the working of English and American locomotives on the same roads, under the same conditions, in Russia, New South Wales, and in South America, states to the Chairman of your Committee that from his observation of English locomotives he does not think their boilers show any greater economy in fuel than ours, when the work done is considered. English boilers generally have smaller fire boxes and more flues than American boilers for the same cylinders. For example, the first locomotive which the Baldwin Locomotive Works built for New South Wales, the general dimensions were as follows: Cylinders, 18 by 24 inches; driving wheels, 62 inches diameter; diameter of boiler, 50 inches; 187 tubes 2 inches diameter, 10 feet $\frac{5}{8}$ inch long; fire box, 72 inches long, $34\frac{1}{2}$ inches wide. They had in New South Wales English locomotives of substantially the same plan, with cylinders and driving wheels of the same dimensions. The boilers however had more tubes, and a fire box 48 inches long by 40 inches wide. They get the greater width by using slab frames. As a matter of fact,

under Mr. Williams' observation, he states that the American engines pulled a greater number of cars than the English locomotives of the same class, and showed a greater economy in the use of fuel per car per mile.

The Chairman of your Committee made a series of tests of temperature in the smoke box of four freight and three passenger engines on the Jeffersonville, Madison & Indianapolis Railroad a few weeks ago, the results of which are set forth in Table A, together with the proportions of the boilers, weight of train, speed, and other matters relating to the circumstances under which the tests were made.

The tests of temperature in the smoke box made on the Jeffersonville, Madison & Indianapolis Railroad with the freight engines were all over the same part of the road, going in the same direction, using the same kind of coal, and on the same trains (night freight). The distance run for each test was 38 miles. The distance run in making the other tests are given in Table A.

The tests with passenger engines were over the same part of the road, going the same way, the runs testing smoke-box temperature, being 49 miles; all other particulars are set forth in Table A. In each case the temperature indicated by the pyrometer was recorded every thirty seconds, and the steam pressure noted every minute.

The instrument used was one of Ashcroft's pyrometers, the stem of which was placed diagonally across the smoke box, 6 inches from the tube sheet. Before making the tests the pyrometer was carefully tested with a mercury thermometer graduated to the boiling point of mercury and adjusted so as to indicate the same temperature, and there is every reason to think the instrument was correct, or at least as reliable as such instruments usually are.

The tests of temperature in the smoke box while the engines were doing their ordinary work were made in order to determine the temperature of the gases (the product of combustion) as they pass out of the tubes into the smoke box, when they no longer serve a useful purpose in the generation of steam, if we except perhaps the effect produced by superheating the steam on its way to the cylinders in passing through the heated pipes in the smoke box. A column in Table A gives the average temperature in the smoke box of a num-

ber of different engines—those on the Jeffersonville, Madison & Indianapolis Railroad for a continuous run of 38 miles with freight trains and 49 miles with passenger trains for each test.

While standing, and with only the natural draught, the temperature in the smoke box was from 375° to 450° Fahrenheit, the steam pressure at the time being from 100 to 138 pounds per inch. When starting a train with a full pressure of steam the temperature would in many cases increase as much as 400° in two minutes, going up as high as 875°, 900°, and 925° within three minutes of the time of starting. It might be supposed that the smoke-box temperature and the steam pressure of the boiler would bear a close relationship to each other; yet this was not the fact. The temperature depended on that generated in the fire box and the strength of the draught at the time. Other things being equal, the stronger the draught the higher the temperature in the smoke box, was the rule. The draught being strong, the gases pass through the tubes in so short a time that but little heat is imparted to the water surrounding them, by a given volume of the gases, as compared with what would occur if more time was given.

The temperature of the water due to a steam pressure of 140 pounds is in round numbers 350°, and if the temperature is increased, the pressure is, of course, correspondingly increased, and *vice versa.* Temperature always tends toward an equilibrium; if that of the gases is higher than the water surrounding them, the tendency to equilibrium will cause heat to pass to the water. The rapidity of its passage, in point of time, will however depend upon the difference in the temperature of the two. The greater that difference the more rapid its passage, other things being equal. This fact may be proven by placing two pieces of metal of the same kind and cubic contents in perfect contact, the one piece being of a temperature 2° higher than the other; then note the time that elapses until both are of the same temperature (the one losing 1°, and the other gaining as much); then take the same two pieces and increase the temperature of one to say 500°, while the other is at 70°; then place the two in contact, and note the time required to raise the temperature of the latter to 71°, and reduce that of the former to 499°. It will be found that in the latter instance the time is much less than in the former. In any case, however, *time* is required; it is an

s.	Smoke Box Temperature, Deg. Fah.	Diameter Exhaust Nozzles............	Number of Cars in Train..........	Speed per Hour....	Train..................	Weight of Engine and Train.......	Pounds of Engine and Train one mile to one pound Coal..	Ruling Grade, Feet ber Mile.....	Miles Run—Test...
s.	Degree.	Inches.		Miles.		Tons.			
..	908	$2\frac{3}{4}$	6	28.64	Passgr	196	6,643	41	904
..	....	$2\frac{7}{8}$	7	28.31	"	182	6,192	41	1,130
..	927	$2\frac{3}{4}$	6	34.77	"	186	5,334	41	113
..	944	$2\frac{3}{4}$	7	34.77	"	216	5,745	41	113
..	908	$2\frac{3}{4}$	....	19.26	"	464	11,670	41	113
.	855	$2\frac{3}{4}$	....	19.26	"	227	9,480	41	113
.	778	$2\frac{3}{4}$	30	....	Freigt	556	11,136	41	536
.	897	$2\frac{3}{4}$	33	....	"	612	12,244	41	1,093
.	....	3	5	30.	Passgr	161	10,380	30	393
.	....	$3\frac{3}{8}$	7	38.50	"	224	....	....	....
	734	3	30	16.46	Freigt	653	15,920	30	108
	714	3	27	19.35	"	....	....	30	108
	712	$2\frac{7}{8}$	29	14.52	"	652	19,460	30	216
	673	....	25.5	15.20	"	....	....	30	108
	827	$2\frac{3}{8}$	14	15.	"	333	10,025	30	108
	783	$2\frac{7}{16}$	26.5	16.	"	572	13,760	30	216
	721	$2\frac{3}{4}$	26.5	17.50	"	....	....	30	216
	739	$2\frac{5}{8}$	21	16.50	"	465	15,840	30	432
	797	$2\frac{5}{8}$	5	33.10	Passgr	193	....	30	108
	779	$2\frac{5}{8}$	4	35.30	"	167	7 952	30	432
	713	$2\frac{3}{4}$	4	35.30	"	168	9,150	30	432

‡Hollow stay bolts, closed—Train No. 6.

*Hollow stay bolts, open—Train No. 6.

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Now, if the gases leave the tubes and pass out of the stack at a temperature of about 400° above that of steam at 140 pounds pressure, the question naturally arises: Can not a portion of this surplus heat be utilized by a change in the proportions of our boilers? If these heated gases could be retained longer in contact with the cooler water surface, a proportional quantity of their heat would be absorbed by the cooler body; and if absorbed it would give out its equivalent in work done by the engine.

How, then, can the heated gases be retained longer in contact with the water surface (heating surface)? To produce a high temperature in the fire box, a good draught is absolutely necessary to supply the requisite oxygen, that combustion there may be as nearly perfect as possible. The nearer perfect it is, the higher the temperature of the gases will be which are the product of that combustion, other things being equal. After the chemical changes known as combustion have taken place in the fire box, generating the highest temperature due to the fuel used, the desired object then is to retain the heated gases as long as possible in contact with the heating surface, so that as much heat as possible may be absorbed by the water. How, then, may this object be accomplished? If we assume that a boiler with a given size fire box has 100 tubes, 2 inches outside diameter and 11 feet long, we would have in this case a tube surface of about 521 feet, measuring the inside surface. The area of the holes (inside diameter) would be about 258 square inches. Now, if double the number of tubes of the same diameter and length be placed in this boiler, then the tube surface and the area of holes will be doubled, and the same volume of gases would have double the time in passing through, and having double the time, more of the heat would be absorbed by the water, without in any way interfering with the draught or process of combustion in the fire box. The draught of air into the fire box should be better in the latter case than in the former, for the reason that the tube area is greater, and consequently less friction from an equal volume of gases passing through in a given time, and the influence of the exhaust in the smoke stack would be more effectual in supplying air to the fire box than in the case of the smaller number of tubes.

How much more of the heat would be absorbed by the water by this increase of tube surface, we do not know to a certainty. Neither

is it known what proportion of the steam generated in the boiler is from a square foot of the fire-box surface, and what from a foot of tube surface. These are matters which have never been determined in the case of a locomotive boiler so far as your Committee are aware, but which would be of value in determining the best proportions if known. By doubling the tube surface we would not, however, increase the value of that surface for evaporation in an equal degree, for the reason that, as the temperature of the gases decreased by being longer in contact with the cooler surface, the difference in temperature would become less, and consequently the passage of heat from the one to the other would be slower, as in the case of the two pieces of metal referred to above, when the original difference between them was but 2°. By largely increasing the number and area of the tubes, the draught through them would be correspondingly slower, and when not sufficiently strong to carry the cinders and small coals which lodge in them through into the smoke box, some would stop up and cause more or less trouble and expense in keeping them clean. How much the tube area may be increased without getting to a point where its advantages will be counterbalanced by disadvantages, we of course are unable to determine. We believe, however, that, as a rule, locomotive boilers as proportioned in this country are deficient in heating surface, particularly so in the tube surface. We are led to this conclusion from the experiments we have made in the temperature of the gases after they have passed through the tubes and become waste heat. We find that when they are thrown away, so to speak, that they still have a temperature of about 400° above that of the steam in the boiler, and it is to this waste of heat that we call the attention of Master Mechanics and others interested in the economical working of our locomotives. The heat generated in the fire box represents the cost of the fuel, and if any of it is wasted, it is equivalent to a proportionate waste in the purchase of the fuel.

It is not probable that any boiler can be adopted for the locomotive which will utilize or take up all the heat from the gases above that of the steam within it, yet, when the greatest economy in the operations of our railroads is a matter of necessity, it would seem that we should make further efforts at obtaining greater results in work done to fuel consumed than has been done heretofore, by endeavoring to

proportion our boilers so as to extract at least a portion of the heat, which our tests have shown is constantly being carried through and out of the tubes while the engines are doing their work, and which is practically wasted. As regards economy in fuel, much depends also on the care and judgment exercised both in running and firing the locomotive, and the condition of the heating surface as to scale, as well as on the proportions of the boiler.

Further, upon the subject of "the best proportions," your Committee have received the following communication from Mr. Howard Fry, Superintendent of Motive Power of the Philadelphia & Erie Division of the Pennsylvania Railroad Company, giving the proportions of the best patterns of English locomotive boilers in tabular form; also, that of some of the best American patterns, together with sketches of some of each. Mr. Fry's very valuable and interesting contribution to our report is as follows:

WILLIAMSPORT, PA., May 5th, 1879.

REUBEN WELLS, ESQ., Chairman Boiler Committee,
American Railway Master Mechanics' Association:

DEAR SIR—Herewith I beg to submit for the use of your Committee a table giving some leading dimensions of English locomotive boilers. The figures are all taken from private information in my possession, and represent the best and most recent practice.

I have added to the list similar dimensions of three American locomotives by first-class builders. You will note that there is no material difference in the proportions of grate and fire-box surface between the American and English engines designed for similar work. Thus engines A, B, F, I, and U are nearly alike in these dimensions. The principal difference is in the flue surface, which is greater in English than in American practice. This extra surface is gained by using smaller flues and more of them. You will, however, note that the proportion between the diameter and length of the tubes, or as it is technically termed the "calorimeter," does not greatly vary. A calorimeter of about 80 may be taken as representing the best practice in both countries.

Attached to this report are a few rough sketches, which will serve to indicate the general outlines of English boilers of recent design. The prevailing feature is extreme simplicity of form. The raised wagon tops and the large domes, which greatly weaken American

PRO

DESCRIPTION OF EN		
MAKER.	CLAS	
Baldwin's	Passenger..	A
Schenectady	Passenger..	B
Atlas Works	Passenger..	C
London, Brighton & S. C. Railway	Passenger..	D
London N. W. Railway	Freight.....	E
Midland Railway	Passenger..	F
London, B. & S. C. Railway	Freight.....	G
Great Northern Railway	Passenger..	H
London, Chatham & Dover Railway	Passenger..	I
North Staffordshire Railway	Passenger (	J
Canadian Railway	Freight.....	K
Bristol & Eastern Railway	Freight.....	L
North-Eastern Railway	Freight.....	M
Caledonian Railway	Freight.....	N
Glasgow & S. W. Railway	Mixed.......	O
London & S. W. Railway	Passenger...	P
South-Eastern Railway	Passenger...	Q
Lancashire & Y. Railway	Freight......	R
Metropolitan Railway	Passenger (	S
Great Eastern Railway	Freight......	T
London & N. W. Railway	Passenger...	U
Brooks Locomotive Works	Passenger...	V

boilers, though in justice to the manufacturers I will say they most always recommend a simpler form than the one now unfortunately so popular. Within the last few years crown bars have been frequently dispensed with in English practice, and the simpler form of staying with through bolts adopted. This plan, which was used by Henry Tyson twenty years ago on the Baltimore & Ohio Railroad, is still sometimes used in America, but not so frequently as its merits deserve. Brick arches are largely used in both English and American engines, but the deflecting plates above the fire doors, which are absolutely necessary to insure a proper combustion of smoke, though most always used in England, are rarely seen here. In England, the fire door is often made to open inward, so that the deflector is only in position when firing is going on.

In the construction of ash pans and dampers, the English take great care to have a means of checking the draught to the fire. The ash pan is made of plate at least $\frac{5}{16}$ inch thick, and stiffened with angle iron to prevent warping, and the dampers are arranged to close air-tight, and are operated either by a lever and notch plate, or by a screw, so that the fireman can, by regulating the opening, control the steam without recourse to the objectionable practice of opening the fire door.

The superior economy in consumption of fuel by English engines can not, of course, be all credited to the boiler. The valve gearing, the arrangement of the cylinders, especially as regards the position of the steam and exhaust ports, and the great care taken in educating the engine-men, are all important factors in the question of fuel consumption. That the English engines are very economical, an inspection of their fuel reports will show. Looking over a number of such reports in my possession, I note that on one line, with frequent grades of from one in 50 to one in 200, and hauling passenger trains equal in weight to seven American coaches, with stops at intervals of every three miles, engines with cylinders 16 by 24 inches and four wheels coupled, burn 35 pounds per mile. Express engines on a level line, making an average speed of 45 miles an hour, with train equal to six American cars, burn from 21 to 25 pounds per mile. On another line, with grades of one in 50 and one in 100, express engines hauling trains equal to seven American coaches, at a speed of 47 miles per hour, burn 27 pounds per mile, this being

the average of a number of engines, and not the best performance of any one.

Freight engines on the line last referred to haul 45 English wagons, probably equal to 25 of our loaded box cars, consuming 45 pounds per mile. Another line reports an average consumption of 35 pounds per mile, with an average train of 55 wagons, the engine being 17 by 24 inch cylinders and six wheels coupled.

On one line, the express engines, with 16 cars, weighing 10 tons each, burn 27 pounds per mile, and on another railway the express engines, with 10 cars, burn 26 pounds, the speed in both these cases being 45 miles per hour.

The methods by which such economy is produced are well worth study, and it would be an interesting experiment if some American railway company would purchase an English engine of a type suited to its service, and ascertain by actual experiment if similar results are attainable in this country.

Yours, very respectfully,

HOWARD FRY.

Your Committee are under obligations to Messrs. Jacob Johann, Jas. Sedgley, S. J. Hayes, Howard Fry, Jas. M. Boone, Wm. Fuller, G. A. Coolidge and others for valuable statistics and information furnished us, and which we present as a part of our report.

Respectfully submitted,

R. WELLS, *J., M. & I. R. R.*
S. J. HAYES, *I. C. R. R.*
C. R. PEDDLE, *T. H. & I. R. R.*
J. JOHANN, *Wabash R. R.*
JAS. ECKFORD, *C., H. & D. R. R.*
} *Committee.*

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I will state that I have diagrams showing the temperature in the smoke boxes while the engine was running 38 miles, which were carefully taken with a pyrometer, and the members can examine them at their leisure.

On motion, the report was received.

Mr. Setchel, Little Miami Railroad—Mr. President, as we have had a continuous session now for four hours without any recess, no doubt the members are weary, and do not desire to enter into a discussion of so important a question at this time. I therefore move we now adjourn to meet to-morrow morning at 9 o'clock.

Motion carried.

THIRD DAY'S PROCEEDINGS.

President CHAPMAN in the chair.

Convention called to order at 9 o'clock.

THE PRESIDENT—The next business in order is the continuation of the discussion of the report on the best material for wheels and axles, which was read yesterday, and the discussion of which was interrupted by the special order for 10 o'clock.

Mr. HAYES, Illinois Central Railroad—Mr. President, in regard to the cost and wear of tender wheels, I gave a tabulated statement in my report to the Committee of the cost per thousand miles, and I supposed the report of Committee would be made in that form. I desired to obtain some information in regard to that matter, and I believe I said in that report we were using steel-tired wheels, but I should have said cast-chilled wheels. This being the time for economy on all railroads, we would all like to know just what it costs per thousand miles to run different make of wheels. In my report to the Committee, I stated that it cost us 7 cents, and, I believe, paper wheels cost 9 cents per 1,000 miles. I would like to hear from the gentlemen present as to their experience.

Mr. JOHANN, Wabash Railroad—Mr. President, I received circular from the Committee, but I think it asked how many wheels and of how many different kinds in use, and what mileage they made before being taken out. I simply stated that fact, and did not give the cost per thousand miles. I would like to ask Mr. Hayes how he counts the cost per mile, whether he simply counts the cost of the wheels, or includes the labor of fitting them up, etc.?

Mr. HAYES, Illinois Central Railroad—Mr. President, in answer to Mr. Johann I would state that we keep an accurate account of all wheels used. We have the cost of the wheel in the first place and the cost of putting them on the axle, and then we keep an accurate account of all old wheels, which are credited to this account, and thus we are able to obtain the cost per 1,000 miles very accurately.

Mr. JOHANN, Wabash Railroad—Do I understand you give credit for the scrap wheels?

Mr. HAYES, Illinois Central Railroad—Yes, sir; we give credit for the scrap wheels at market price, and I find they cost a little more than 7 cents to the thousand miles. I saw a long statement from a gentleman representing the paper wheel with steel tire, and he gave figures at 9 cents per thousand miles, which he thought was very low, and it surprised him very much when I showed him it only cost us 7 cents. It is my object in discussing this matter to get the experience of other members so we can see what it does cost.

Mr. JOHANN, Wabash Railroad—Mr. President, my idea would be to have the different roads keep accounts in the same way, and I would call the attention of the members present to the importance of this question. It is one which I think would be desirable to investigate and draw out the facts in regard to it. As it is now, it seems rather indefinite. We should adopt a standard rule for keeping wheel records. It is a matter about which you can not get any definite information in one year; but we can commence now and keep a record, and perhaps by next year we may have something definite to report.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, there is one question which I suppose would be difficult to get at, and at the same time it ought to be considered in this connection, and that is the interest on the increased cost of the steel-tired wheels over and above the cost of chilled wheels.

Mr. HAYES, Illinois Central Railroad—Mr. President, I have been informed by several different wheel makers recently that it is becoming customary for representatives of roads to buy their wheels by the thousand miles. For instance, some of them contracted for 10 cents per 1,000 miles, some for 12, others for 14, and some as high as 22 cents, which astonished me, as ours only counts up to 7 cents. I would state that we make our own wheels. Of course, we do not charge any interest on the cost of the foundry or for tools. We charge all material and labor pertaining to the foundry to the kind of equipment for which the wheels are made. We can, of course, make them pretty cheap, but I had no idea there was so great a difference as there seems to be, and I want to get posted in the matter.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I would like to ask Mr. Hayes, what their wheels cost them per ton or per single wheel, which he figures in that way?

Mr. HAYES, Illinois Central Railroad—They cost between eight and nine dollars per wheel, or say $1\frac{3}{4}$ cents per pound, allowing credit for the old wheels at their market value, which is about eighteen or nineteen dollars per ton.

Mr. SPRAGUE, Porter, Bell & Co.—Another question I would like to ask is if in purchasing wheels by the thousand miles, is the price of the old wheels deducted at market value of scrap, or is that the full price of the wheels?

Mr. HAYES, Illinois Central Railroad—It includes the whole cost.

Mr. SPRAGUE, Porter, Bell & Co.—Well, then I should think you should give the railroad companies credit for the cost of fitting up the wheels with axles and putting them under the car and tenders, etc.

Mr. HAYES, Illinois Central Railroad—I understand the contract between the railroad companies and the wheel makers is that the railroad companies keep back a certain percentage, and then pay them every month or quarterly for the wheels, and out of that percentage they take the cost of taking out and putting in the wheels.

Mr. DEVINE, Wilmington & Weldon Railroad—Mr. President, if I understand the matter, the contract is so much per thousand miles; but the wheel makers claim the old wheels, and you have to return them or give them credit for the old material.

Mr. SPRAGUE, Porter, Bell & Co.—I move the discussion on this subject be closed.

Motion carried.

THE PRESIDENT—The next business in order will be the discussion upon boilers.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I did not intend to make any speeches on this subject, the Committee having presented their views pretty fully in the report; but for the purpose of bringing up some discussion, I will just mention a few points that have been introduced by the Committee. In reference to the best material for the shell of locomotive boilers we find some difference of opinion. In some localities parties using a large number of boilers find by experience that iron gives better satisfaction for the shell of the boiler than steel, owing to the tendency of the latter to pitting and corroding in the bottom, and in some places iron is preferred for the crown sheets and fire boxes, owing to the fact that steel gives more trouble by cracking round the rivets and in the crown sheets. I suppose scale falls upon the sheet and becomes overheated, and the result is in time it will crack in the rivet hole and in that way give trouble, while others say iron under the same circumstances does not crack so readily, and therefore less trouble is experienced. These are the points that I wish to present to the Convention for discussion on the subject of material. If no one desires to discuss that portion of the subject, I will pass to the next.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I would like to ask if there is any one here who is using Bessemer steel for boilers. I am building one boiler to be made entirely of Bessemer steel for a company interested in the Bessemer steel business, which I suppose is more of an experiment than any thing else. But I wish to inquire if any body here has used that material for fire boxes.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, in answer to Mr. Sprague's question I will state that we have used the Bessemer steel for fire boxes, but not with any degree of satisfaction. The prevailing fault of the Bessemer steel is that it will blister on the inside of the fire box.

Mr. HAYES, Illinois Central Railroad—Mr. President, I have been on this Committee upon boilers and boiler material ever since the organization of the Association, and I have made quite a number of reports as chairman, and have been associated with the committees, I think, for the last three reports, and in every case until the present time I have recommended steel for nearly all, if not for all, parts of the boiler. I think in my first report,

however, I said that I was troubled with incrustation upon the crown sheet, and on that account would prefer good iron; but after introducing a way of washing the crown sheets, I was able to keep them comparatively clean. I then commenced the use of steel, and since that time it has given better satisfaction for the crown sheets than Low Moor iron. In the cylinder part of our steel boilers I find they pit and furrow rather more than good iron, but not more than some iron. This is one of the subjects I would like to hear fully discussed—whether it is best to use steel or iron for that part of the boiler. I am perfectly convinced, however, that steel is better for all the other parts. We have been troubled with pitting and furrowing more on some sections of the road than others, and this trouble seems almost entirely confined to the sections of the road where the water is strongly impregnated with lime, and upon this point I would like to hear the opinion of the members. I have attributed the trouble to both mechanical and chemical action. We have some trouble in the longitudinal part of the boiler, it being cold; when the fire is started it gets heated and expands, and cools quicker than at the part near the furnace. I have very seriously thought of abandoning steel for that part of the boiler, unless some of my friends here can give me a remedy for the trouble. I would therefore like to get an expression upon this point.

THE PRESIDENT—If there is no further discussion upon this section of the report we will proceed to the next.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, the next question is the best manner of constructing a boiler. The only point brought to the notice of the Committee is, which would be the best form that would be practical to adopt in the construction of a locomotive boiler. For strengthening the seams, the welt joint is pretty generally in use, which was illustrated on the black board yesterday; annealing the flanged sheets so as to remove them from any strain that might result from flanging; and another matter was that of corrugation in the sheets of the fire boxes, and whether corrugation is a preventative from rupture. Several years ago, after steel came into general use for fire boxes, a great deal of trouble was experienced on many roads by sheets cracking. It was found on roads where this difficulty occurred that they used water that formed very hard scale, and from that cause sheets were overheated, and consequently were brought into a condition that when they were cold and under a tensile strain they ruptured from that cause. Then it was suggested and put in practice by a great many that corrugation would remove that strain, and a very large number of corrugated fire boxes are now in use. So far as the Committee have had reports from those using these fire boxes very good results have been obtained. But your Committee would like to hear a general expression from the members present who are using corrugated sheets, as to whether this method is a preventative of rupture and leakage of the stay bolts, as that is one of the most important things connected with the construction of

locomotive boilers. If fire boxes can be so constructed that there is no danger from rupture or leakage, we will have reached a point that is worth something; and so far as my experience goes, I will say that I have used corrugated sheets for a little more than three years, and have never had any trouble from this cracking, nor never had any leakage from the stay bolts, whereas, when we used the plain sheets, we had a great deal of trouble. Another matter brought to the attention of the Committee, is the washing out of scale, sediment, etc. Mr. Hayes has given a method of washing out boilers, which is shown on the drawing here, to which the members can have access at any time. Mr. Johann has a method also, which is worth consideration. I would be glad to hear discussion upon this point.

Mr. Sedgley, Lake Shore & Michigan Southern Railroad—Mr. President, for several years we were having a great deal of trouble with rupture in side sheets, and it became a very serious matter with me whether we could continue to use steel for fire boxes. I commenced corrugating the side sheets of our furnaces. At first I put a half dozen corrugations one inch deep, and after having run them a year or two, it occurred to me that that was a little more wave in the construction of the boxes than was requisite, and I changed the waving part, putting in three waves about ¾ of an inch, extending up from the mud ring, and this prevented our side sheets from rupture. As regards our stay bolts, we have no trouble with them when properly put in. I apprehend that a large amount of that trouble arises from the improper manner in which they are put in. In 1868 I drilled all the holes in my boilers. Now you all know there is a great deal of work attending it, and I have since changed to punching them and annealing the sheets afterward, which gives good results. My own preference is for punching and annealing rather than drilling without annealing. After ten years' experience I find no reason for abandoning steel boilers, and I am somewhat surprised at the statement of my friend Mr. Hayes in regard to his boilers corroding and pitting, as my experience has been just the opposite.

Mr. Young, Cleveland, Columbus, Cincinnati & Indianapolis Railroad—Mr. President, we have recently put in some fire boxes of low grade steel, with which we have had no trouble with side sheets cracking. I think we are using too high a grade of steel, as none of our boxes have ruptured since we commenced using the low grade, and I think the greater part of this trouble is in the quality of the steel rather than the corrosion of the sheets. It would not be fair to condemn the manufacturers of low grade steel unless it is due them.

Mr. Sedgley, Lake Shore & Michigan Southern Railroad—Mr. President, in answer to Mr. Young I will state that we are using equally as high grade as ever, and I am somewhat of the opinion that we get better results with a large amount of carbon than with a low grade of steel for our furnaces. I do not know of a case where waving the sheets has not prevented rupture.

Mr. Miles, of Philadelphia—Mr. President, I think my friend Mr. Graham can give some information in regard to corrugated sheets.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—Mr. President, I have been using corrugated fire boxes for the last eight or nine years. I have had no trouble from ruptures in them, and I have used iron as well as steel, and there is no difference that I can see except that there is little more liability in the iron to blister. We washed out a boiler last week from which we took about three bushels of scale. The same engine had been washed out about four weeks before, but the water on our road is very bad. I have a sample of the scale with me, which will speak for itself.

Mr. HAYES, Illinois Central Railroad—Mr. President, I apprehend that we all have a different experience in the use of steel of the same grade, on account of the difference in coal and water in our several localities, especially in this cracking about the stay bolts. For instance, take the section on our road from Amboy to Clinton, where we are using coal from the region of the Illinois River, we had a few fire boxes crack, while on other sections of the road, where we use coal something like charcoal in engines running the same length of time and in the same service, there will be no trouble with the fire boxes. I have some engines that have been running for nine years with plain fire boxes made of crucible steel, and there is yet no sign of crack in them. I do not know how long they will keep that way—they may crack to-morrow; but if I take one of these engines and put her on the Amboy Section, where the coal is strongly impregnated with sulphur, I presume it would not run one-quarter the time. Consequently we can not determine exactly as to the kind of steel that is best adapted to every locality. We have one or two engines with corrugated sheets which are doing very well. I presume the coal Mr. Graham is using is free from sulphur.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—No, not entirely.

Mr. HAYES, Illinois Central Railroad—I judge there is not much.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—No, not very much.

Mr. HAYES, Illinois Central Railroad—I think if you were using coal strongly impregnated with sulphur, you would find a different experience. Considering what you have stated with the different character of coal, etc., I believe the low grade of steel is giving the best general satisfaction.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I would like to add my testimony in favor of corrugation. It is now nearly four years since we commenced that practice. Previous to that we had used plain boxes of crucible steel, and were troubled very much with cracked sheets; but since that time we have not had one.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I would like to ask what the objection is to low grade steel. It has always been my opinion that what we want for fire boxes is a perfectly homogeneous low grade metal. I think some of this trouble is caused by the punishment sheets go through in flanging. As a rule, whatever will stand flanging the best will probably stand in service the best.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. Presi-

dent, about two years ago I made some experiments upon the expansion of sheets. I took a piece of steel similar to the side sheet in the fire box, and which was illustrated and explained at our Convention two years ago at St. Louis. If all had taken a good look at that and noticed the difference in the expansion of the side sheets, you could not help but understand the forces which are at work in the sheets of a fire box. You notice in firing up the plates six inches above the grate will expand as much as $\frac{1}{16}$ of an inch more in length than that part higher up. To prevent this you must endeavor to get the water in the box of an even temperature. About six months ago, in conversation with a gentleman connected with one of the largest railroads in the West, he told me that he had a very large number of fire boxes on his road made of a very low grade of steel by manufacturers of as good reputation as any in this country, and to my surprise he said he had some ruptures in corrugated sheets of this steel. The kind of sheets used before were straight, not giving any wave or corrugation. I suggested that bad water might be the cause, but he said the water was very good. A few months ago I received a communication from Dr. Williams, of Baldwin Locomotive Works, inquiring as to what my experience had been in the use of corrugated fire boxes, and saying that if it would prevent rupture and so mcch leakage about the stay bolts it would be of great advantage, as it would enable them to compete with builders using copper, and I said to him that I thought corrugation would do it. I would like to ask whether any one has any thing to say in regard to the method of removing scale under pressure from the boiler. It is one of the points that comes under this head. There is a diagram here of an arrangement which is used by Mr. Johann, and perhaps some of the members would like to look at it. I also have one by Mr. Hayes.

Mr. JOHANN, Wabash Railroad—Mr. President, perhaps Mr. Hayes would like to explain his first.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I think the better way would be to pass the drawing around and let the members look at it, and the drawing will explain itself.

Mr. HAYES, Illinois Central Railroad—Mr. President, the drawing represents a pipe extending all around the engine house, two inches and a half in diameter, and over each engine there is a connection that we make from the pump to this pipe with a hose, through which we can blow out the steam into the tank which stands back of the engine house, and when we want to use it for washing out we open the cock and turn on the pump which we use in case of fire. The pump keeps up a pressure of from 70 to 100 pounds to the square inch, and from this pipe overhead we attach a hose and wash our boilers out. We keep up a pressure of about 100 pounds. We force the water in, and any scale that forms there during the round trip we wash off. We have been using this now for two years, and have not found any scale on our crown sheets since, and before it was introduced we found about $\frac{1}{16}$ of an inch scale in running the round trip, which was one of the great

causes of the crown sheets cracking. Since this has been introduced we find our repairs upon boilers has been reduced some 25 per cent. I find it most convenient to run this pipe into the round house, where it also answers for fire purposes. Mr. Johann has made a decided improvement upon the plan, which he will explain.

Mr. JOHANN, Wabash Railroad—Mr. President, so far as the material for boilers is concerned I have a word to say. I have listened from year to year to the explanations of members here, and I have found the general expression of opinion tends towards fastening the causes of failure of different materials upon the manufacturers. I long ago gave up that charge, and turned my attention towards taking as good care of my boilers as possible, to see what effect that would have. For a considerable time we have been using steel for fire boxes, and if we did not think it was the best material we certainly would not use it. In addition to using steel for fire boxes I have also, for a number of years, been using it for the shell of boilers, and am now using it for stay bolts, thereby making the entire boiler of steel, and so far I am entirely satisfied with it as a material for that purpose. I have not had a particle of trouble with my side sheets since I have been using it, and from my experience I have arrived at the conclusion that steel is the best material for locomotive boilers and fire boxes; and if some of the members will come up and see me, I am positive that I can convince them of that fact. In my opinion, if proper attention is given to boilers there will not be so much trouble. One difficulty is that some men will carry too much fire. I have found that, with the quality of coal we use on our road, five or six inches of fire is sufficient, and gives the best and most economical results, and any man who is found carrying more than that is severely reprimanded. As for the best method of keeping boilers clean, I for a long while used the mud drum, but it did not seem to perform its functions properly, and in looking around for something better I learned of Mr. Hayes' method. I made what I consider an improvement on his plan, and I can add my testimony to his, that it is the best thing I ever used for cleaning out boilers. I will state there is no patent on it, and if any member desires to use it he is at perfect liberty to do so, and, so far as I am concerned, I will be pleased to furnish him with tracings. In using it all you have to do is to attach the force-pump hose and force the water through, when you will be astonished to see how thoroughly it breaks up and drives out the sediment. Another great advantage in using this device lies in the fact that it enables us to cool the boilers slowly. This is done by opening the blow-off cock and allowing the pressure to fall to fifty or sixty pounds, when the cold water is forced into the boiler, gradually at first, and then increasing the pressure until it reaches from 70 to 100 pounds. Before using this device I have frequently taken out from 1,500 to 2,000 pounds of sediment; now, upon inspecting any boiler fitted with this device, the rivet heads are seen as plain as when the boiler was first made.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, two years ago at St. Louis, in our discussion upon boilers and fire boxes, I was reported as being in favor of copper fire boxes. I would like to place myself upon record that I am entirely opposed to copper for fire boxes, and I have not had any in service since 1855. All the fire boxes that I have put in lately have been of steel, and it has been my opinion for some time that steel is the best material for the entire boiler; but I think the low grade steel is preferable for fire boxes. In putting in fire boxes I drill all the holes for the rivets and stay bolts, and afterwards anneal the sheets thoroughly. We do not use corrugated boxes, and have no trouble with side sheets cracking. In regard to cleaning boilers, when it is possible, I am in the habit of admitting the cold water at the same time the hot water is running out, and thus letting the boiler cool gradually, until it is in a condition to be washed out, which process prevents unequal expansion and contraction of the sheets and the hardening of the scale by heat, as will be the case when blown out suddenly.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I do not know but what I would like to say a word in regard to this matter. I have been to conventions when, perhaps, I have talked too much; but before I came here I made up my mind I would not. The subject of boilers is one of the most important we have to consider, as, perhaps, more depends upon that than any other part of the locomotive. We build boilers with the object of getting the most use out of them possible; and as to the material of which these boilers should be made, I am very much in favor of steel, and for the last three or four years I have not built any other kind. In regard to corrugation, I am in favor of corrugating all the sheets of the fire box except the crown sheet. There is one thing that I have discovered, and that is that nearly all the corrosion takes place where the coal contains a great deal of sulphur. I find no difficulty with corrugated sheets; but I think the chief benefit is derived from thorough washing out of the boilers. If you can put on a pressure of fifty to one hundred pounds, you can knock out all the scale by force. Last year we had some Mogul engines built by the Schenectady Locomotive Works, of which the fire boxes were 66 inches long by 35 inches wide and 62 inches high, or something like that, and had 170 two-inch tubes. They came on the road over a year ago, and have been running up to the present time on the main line between Chicago and St. Louis and between Bloomington and Chicago. Some of the tubes in these engines have given out. If we can get tubes to run eighteen months we think we are doing well, and we have sometimes taken them out much sooner. I think, however, the cause is mainly from bad water and the sulphur in the coal.

Mr. ORTTON, Canada Southern Railroad—Mr. President, I think if the boilers are thoroughly washed and kept clean we can prevent a great deal of the cracking. I think it is more in imagination than fact that corruga-

tion is a preventative of fracture. The difference in the quality of the coal having more to do with it in my opinion than any thing else. I agree with Mr. Johann that steel is the best material for fire boxes. There is another thing I would like to say, and that is if you keep your inside sheets clean the water will prevent a great deal of this expansion and contraction.

Mr. HAYES, Illinois Central Railroad—Mr. President, in regard to Mr. Ortton's experience, I think if he would spend a few years in Illinois he would, perhaps, change his mind. I believe there is no road in the country that is more careful and give more attention to washing their boilers than the Illinois Central. It is done every round trip. The engine will leave Chicago and run to Urbana and return, and it is then washed out carefully. If you look into an analysis of this scale that is formed in the boilers you will find particles of lime or ordinary mortar. I have come to the conclusion that to avoid this lime, etc., we must heat the water before it passes into the boiler. If Mr. Ortton got his water from Illinois he would find some trouble with his boilers; but, probably, the water in Canada is cleaner than feed water is generally. We have more trouble on some sections of the road than others. We have more difficulty on the Amboy Section than others, because there appears to be more lime in the water and sulphur in the coal. The only way to keep this lime out of the boilers is to take it out before the water goes in.

Mr. J. H. RAYMOND, of Chicago—Mr. President, I would like to ask Mr. Hayes if he has made any experiments with surface water?

Mr. HAYES, Illinois Central Railroad—Yes, sir, I have; but that is available only in certain sections where drainage from the surrounding country can be obtained.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, when I was on a road in Massachusetts I had but very little trouble with bad water. We could run an engine twenty years without removing the tubes. In the State of Illinois you could not begin to do that, and when I came to the State of Ohio I had serious trouble with sediment and scale, which formed so solid that we had to run rods into the boiler to break it up to get it out. In some sections of the country you will find a great many different kinds of water. We have some sections on our road where the water forms into scale one-fourth of an inch in two weeks.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I would like to say in regard to the corrugation of fire boxes that I have been in the habit for a number of years of keeping the flues three-fourths of an inch apart, so that all sediment would pass through to the bottom of the boiler to be washed out. We should have the boilers as cool as possible before we commence to wash out, and I think the best way to do is to allow them to get cool before putting water in.

Mr. HAYES, Illinois Central Railroad—I do not exactly agree with Mr. Simonds in regard to blowing off boilers while hot and then allowing them

to cool down before washing out. If you examine a piece of scale with a microscope you will be able to tell just how many times the boiler has been blown off, and I do not think it is a good plan to allow a boiler to cool down before washing it out. You can put the water in gradually, and keep it partially warm, and get off a great deal of scale which would otherwise form on the boiler.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I do not think that Mr. Hayes and I disagree at all in regard to washing out boilers. I meant to be understood that in blowing the water out of the boiler and putting in the cold water gradually, so as to keep it partially heated and at the same time take off the scale.

THE PRESIDENT—If there is no further discussion, Mr. Wells will please read the next subject.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, the next subject is the form of the boiler. Some parties report to your Committee that they are using the taper form of boiler, and some also report in favor of the brick arch. Your Committee proposed the question whether the boiler is better with the dome than without, and whether the straight boiler is better as compared with the wagon-top. The Committee have also noted another form of boiler called the Verderberger Boiler, which has been experimented with in Hungary.

THE PRESIDENT—Is there any discussion on that portion of the report?

Mr. HAYES, Illinois Central Railroad—Mr. President, in regard to the form of the boiler I would like to say that I do not think it possible that we can all agree upon that. On some sections of our road I know there is no necessity for the dome, while on other sections it is an actual necessity. I therefore think it would be impossible for us to agree upon a form of boiler to suit all sections, as every part of it, I think, depends upon the notion of the parties building it and the section of country through which it is to run; but the material of which the boiler is to be made is something upon which we can all agree.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, if there is nothing further on this subject, I will pass to the next, which is the best proportion for boilers in order to obtain the best results from the fuel consumed. The question being whether we should increase the grate surface or whether it would be advisable to increase the heating surface. In the diagrams here presented, which were taken of different freight and passenger engines, you will notice a change in the temperature of the smoke boxes. Now the question is whether that heat shall be thrown away by passing into the smoke box, or shall any portion of it be utilized by some change in the form of our boilers. Now you will find one locomotive, for instance, with four or five cars in a passenger train running 35 miles on an average temperature of 700°; another with the same arrangement will run from 700° to 800° difference in the temperature, and steam used at say 140

pounds is not more than 350°. Yet there is a temperature of the gases of 350° or 400° above that thrown away. Now can we utilize this heat by increasing the length of the tubes or putting more of them in the boiler? I would like to hear an expression of the members upon this subject.

Mr. SIMONDS, Cairo & St. Louis Railroad—Mr. President, I have come to the conclusion that the greatest economy in fuel will be obtained by having a larger number of flues, so as to use more heating surface, although I have known of cases where engines have given better results with 160 tubes than with 175.

Mr. HAYES, Illinois Central Railroad—Mr. President, I have been satisfied in my own mind for years that there is a great deal of heat wasted passing up from the smoke box that might be utilized if we built our boilers a little larger. I experimented with a stationary engine and compared the results with engines on the road, and I found between 72 and 85 per cent. difference in heating capacity with the same coal, and therefore I am satisfied if we could build our boilers large enough to avoid this heat from going to waste, we would economize in the use of fuel. If we build them large enough we certainly can utilize 300° of heat, which would amount to a great saving in fuel.

Mr. HEWITT, Toledo, Peoria & Warsaw Railroad—Mr. President, I have had some experience in the use of coal from different mines and different places, in our engines with small fire boxes, small grate area, small number of flues, and small boilers; but the time arrived when we had to have more power in one engine. Our engines at that time were very small; but something had to be done, and they looked to me do it. Our fire boxes ranged from 50 to 54 inches in length, 33 inches wide, 56 to 58 inches high; the diameter of cylinder part 45 to 47 inches. I immediately made up my mind that I would have to have more heating surface. So I put in fire boxes 64 inches long, 60 inches high, reduced the rings in the fire box, got in 35 inches in width with the same number of flues. I enlarged the cylinder one inch, and with these engines I experienced no difficulty in obtaining steam either in passenger or freight service. We had eight of these engines, and I built them all over, and to-day we are making a mileage of from 54 to 56 miles to the ton of coal. I think in order to get better consumption of fuel we should increase our grate area.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I would like to ask the gentleman the size of the cylinder and length of the flues. I believe I have recommended the cylinder part of the boiler to be from 45 to 47 inches.

Mr. HAYES, Illinois Central Railroad—Mr. President, if our friend Hewitt had increased the cylinder part of the boiler in proportion to the increase of the furnace he would get still better results.

Mr. MILES, of Philadelphia—Mr. President, I would just say that I witnessed an experiment on the New York & New Haven Railroad, where the

engine went out on a trip, and one-third of the fuel consumed escaped through the smoke box. What caused this I can not say, as I am not an expert in such matters.

Mr. Jackman, Chicago, Alton & St. Louis Railroad—Mr. President, I think in order to get the greatest amount of heating surface we must increase the size of our exhaust. We can use a larger exhaust if we arrange to utilize the cinders in the smoke box, and you will then get the greatest benefit from your heating surface.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I will just state for the information of the members that this tabular statement shows that engines having the largest proportion of heating surface give the greatest economy in fuel. These matters will be printed in tabulated form, and all can compare them very readily.

On motion, the discussion was closed.

The President—Gentlemen, Mr. Raymond, our newly elected Associate Member, would like to say a few words to the Association.

MR. RAYMOND'S ADDRESS.

Mr. President—I came from Chicago to attend this Convention with the purpose of consulting individually with the members concerning a matter of paramount interest to all. At the suggestion of those with whom I have consulted, and by your indulgence, I will make a few suggestions concerning this matter in open Convention.

The early introduction of the improvements made in railroad appliances and devices is of the first importance to railroad companies. Railroad companies heretofore have in some instances been too slow in the introduction of really meritorious improvements, and in other instances have been too fast in the introduction of improvements that had in themselves no merit, and only served to involve the companies in expensive and tedious patent litigation. As an illustration of the first point, I have recently been making a few settlements under a patent for a real improvement which was ready for introduction thirteen years ago, but which to this day has been introduced only on a very small percentage of the roads composing the Western Railroad Association; and now, when this device is just being called to general attention, another improvement recently patented has just been investigated and found in merit largely to supplant the former device. In many respects we are just that far behind the progress of the age in improvements, that by the

time an improvement has become generally introduced another improvement upon this improvement is patented and ready for introduction, and would be introduced but for the slow methods which have heretofore obtained in this regard. The interest of the railroad companies in reducing the cost of transportation, so that they may meet the necessary reductions in the charges therefor, requires great diligence in the matter of ascertaining and adopting such improvements in appliances and devices as will in any degree contribute towards the desired result. The Association of Managers, of which I have the honor to be an executive officer, has made a start in this direction, and intends to perfect some plan, sooner or later, by which we can sift the wheat from the chaff, ascertain reliably which of the devices made will contribute towards economy and efficiency in the operative department, and ascertain some means of acquiring the right to use such inventions at an early date in their history.

The experiments with these matters which have heretofore been made, whether satisfactory or not as to the roads upon which they have been made, have been practically useless so far as general information is concerned among the fraternity. The technical associations, composed of heads of departments of railroads, so far as giving this information in such a shape as to produce practical and general results and the adoption of standards, have also been practically failures. I need not now discuss the causes of these failures. It is sufficient to say that the determinative reason why this Association has not in its results been more satisfactory to its members, is because it has not employed methods which the managers could approve, nor had in this work the full co-operation of the managers.

The point to which I desire to call especially your attention, and solicit your earnest thought between now and and your next annual meeting, is how to perfect your methods in this work; how to secure the full co-operation of the managers in such methods as you may adopt, and what should be the relation between the Master Mechanics' Association and the Western Railroad Association.

The plan adopted by the Western Railroad Association so far is as follows: Any owner of an improvement who has sufficient confidence in it to pay a fee of $100, and the expenses of a practical test

with it, may make application, and the Association will appoint a board of competent experts to make a thorough examination and a practical test of the improvement, and the results obtained by the Board will be reported by the Association to its eighty members.

It is not our fault that there are now alive 173,000 patents, the majority of which are not practically worth the paper upon which they are printed. This fact constitutes the main reason why the introduction of improvements has been and now is so slow. It is our business, so far as our interests demand it, to accept and overcome these facts. The object of this part of the work of the Western Railroad Association is identical with the main object of this Association, and it is desirable that the two Associations should work in perfect harmony and neither duplicate the work of the other.

I desire only to add a word of caution concerning the adoption of such minor improvements as each of you may make in your own shops. We are now defending many millions of dollars of patent claims, all of which rests upon the use of devices which we have paid at least one patent royalty upon.

I will not detain you to demonstrate how one patent may be perfectly valid and yet the device shown therein may infringe one or more prior patents. I will simply say that it is not safe for you to make any material changes in your devices and processes, and especially any additions thereto, without first receiving the advice of competent patent counsel as to the patent relations of such appliances or processes.

I thank you Mr. President and gentlemen for the attention you have shown me.

THIRD DAY, AFTER RECESS.

THE PRESIDENT—The next business in order is the report of your Committee on long runs, but I understand from the Secretary that there is no report.

THE SECRETARY—The only member of that Committee present is Mr. Cooper, and as I have not said any thing to him about the matter I do not know what excuse the Committee have to offer, or whether there is any.

THE PRESIDENT—There being no report upon that subject, the next business in order will be the report upon locomotive tests, made with a view to ascertain the amount of work done by engines of the same class.

The Secretary has some papers or communications with that report, which he will read.

The Secretary then read the report.

Report of Committee on Performances of Locomotives.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee appointed to report on the subject of Performances of Locomotives would say that, on account of the very few replies received to their circular, they have not been able to make up a report, but think the subject is worthy of still further investigation. Your Committee desire to present to the Association a report of a series of tests made and furnished by our fellow-member J. E. Martin, Master Mechanic of the Chilian & Talcahuano Railroad of Chili, South America, on the Exhaust Nozzle, being a continuation of our report presented last year at Richmond, Va., on Locomotive Tests. The above is accompanied with diagram, indicator cards, etc., and are the actual results of experiments or tests carefully made. Your Committee would recommend that they be printed in the next Annual Report.

Respectfully submitted,

WM. WOODCOCK, *M. M. C. R. R. of New Jersey,* } *Committee.*
S. A. HODGMAN, *M. M. P., W. & B. R. R.* }

CONCEPCION, March, 1879.

To the Committee on Locomotive Tests, Master Mechanics' Association:

EXPERIMENTS WITH NO. 4 ROGER MOGUL FREIGHT ENGINE, CYLINDERS $16\frac{1}{2}$ BY 24 INCHES—"EXHAUST NOZZLES."

GENTLEMEN—In my last paper on the "economical distribution of steam in the cylinder while working in the first notch," I mentioned that exhaust nozzles $2\frac{3}{4}$ inches in diameter were large enough for the perfect escape of the steam at speeds up to and even exceeding 40 miles an hour.

Although that is a fact, as proved by the indicator diagrams, and a careful measurement of the water consumed by the locomotive, it does not follow that an exhaust nozzle of a larger size would not prove economical. That is, by obtaining a milder draught more water would be evaporated per pound of coal, and this economy would be greater than the loss from a too rapid exhaustion of the

steam. This loss could again be decreased by a change in the proportions of the valve, principally lap.

The above remarks refer *only* to the use of steam in the first notch as stated in my paper.

The subject of this paper is "The Exhaust Nozzle," the simplest and at the same time the most important detail governing the economical production of power in the locomotive. The greater the power required, the more important is its effect.

There are two forms of exhaust nozzles in use—the double form, in which each cylinder has a separate exhaust pipe for the discharge of the waste steam, used on all or nearly all American locomotives, and may be called the "American Exhaust Nozzle," and the single form, in which the exhaust pipes from each cylinder unite, and the exit of the steam is made from one common orifice, this form being in use on all English locomotives, or I might say all locomotives but those made in the United States.

Now why should there be two such distinct forms for a detail having precisely the same work to perform in each case? Surely one must be right and the other wrong, or perhaps there are advantages in the one not found in the other.

These experiments were undertaken with a view of deciding this question, and I have attempted to do so in three ways.

1. By showing with the aid of the indicator the effect of the different forms of exhaust pipes on the quality of the exhaust, otherwise the economical distribution of the steam in the cylinder.

2. By a series of experiments with the locomotive in regular work, showing the amount of water evaporated per pound of coal and the amount of coal used in doing the work, the standard being a loaded car moved one mile.

3. By a comparison of the vacuums produced in the smoke box by exhaust nozzles of equal steaming capacity, as measured by a vacuum gauge filled with water and attached to the smoke box.

EFFECT ON THE DISTRIBUTION OF THE STEAM IN THE CYLINDER—"EXPERIMENTS WITH THE INDICATOR."

The manner in which these cards have been taken has been so fully described in former papers that it is needless to repeat it here

They were all taken with the same indicator and spring, and no alterations of any kind were made in the valves. The steam gauge was tested occasionally and always found correct.

It will be noticed that I have not used the conventional terms for the different lines of the diagram, but have adopted another nomenclature, which I find much superior when studying the distribution.

When following the line through the period of admission, what is more natural than to call it the "admission line," that of expansion, the "expansion line."

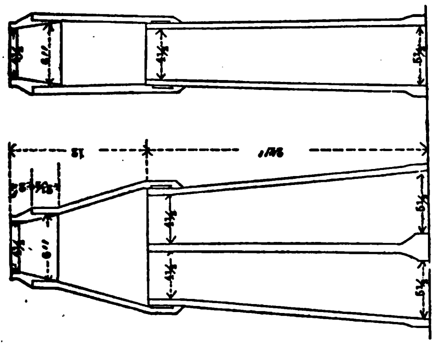
The release of the steam forms a line which may be called the "line of release," and while the port is open to the exhaust, a line is drawn, which naturally forms the "exhaust line." During the period of compression a line called the "compression line" is formed, and during the admission of steam to the cylinder another line is drawn indicating the pressure of steam, which may be called the "steam line."

[NOTE—I had forgotten to mention having used this nomenclature in my last paper, and this neglect may have caused some confusion in understanding my meaning.]

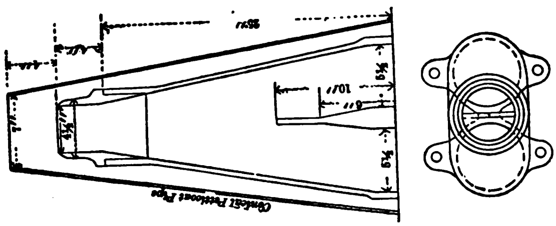
It will be seen from the dates that these experiments extended over a long period of time, from May 23, 1876, to December 25, 1878, during which time, principally the latter part, the engine ran some thousands of miles, and as a consequence the valve gear became worn and caused "slack motion" and a considerable decrease in the amount of lead. This decrease of lead is prejudicial to the economical distribution of the steam, as the steam is not brought up to boiler pressure before the commencement of the stroke, and is not so well maintained during admission, nor is exhaustion so perfect.

As diagrams taken at the commencement of the experiments do not show an excess of lead—in fact, there is not a sufficiency—it follows that those taken during the latter part of 1878 should show an inferior distribution, and to any improvement caused by an improved form of exhaust nozzle should be added this loss, which I would estimate to be about three per cent.

The blast pipes or nozzles used during these experiments are shown in accompanying sketches.



Sketch No. 4.



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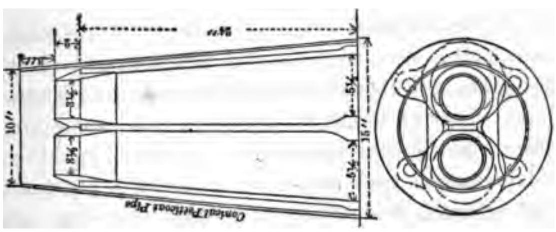
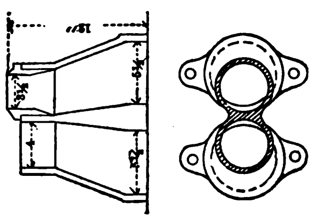


Sketch No. 2.



Sketch No. 1.

Sketch No. 1—Low double nozzle, height 12 inches above bottom of smoke box.

Sketch No. 2—High double nozzle, height 26 inches above bottom of smoke box.

Sketch No. 3—Single nozzle, height 29 inches above bottom of smoke box.

Sketch No. 4—Compound nozzle, being a combination of the two forms, and is 36 inches above the bottom of smoke box.

The three mouth pieces of this form can be altered as in the double and single forms.

I have grouped together for comparison diagrams taken in each notch.

When the card was taken the throttle was full open in every case, and the boiler pressure and other data noted as already described.

A line on each card is drawn to represent the vacuum line, another parallel with it indicates the boiler pressure, and a line at right angles joining these two represents the amount of clearance space between the piston at the end of its stroke and the valve.

The clearance space is in this locomotive .091 of cylinder contents or 465 cubic inches.

Card No. 1.—Is taken in the second notch with the compound nozzle, the double nozzles being each 4½ inches in diameter, while the single nozzle is only 4 inches.

As might be supposed the steam, after leaving the 4½ inch nozzle, is again compressed through having to pass out of an orifice smaller than 4½ inches, and this after expanding to fill the larger space above the double form of nozzle or blast pipe. This compression of the steam forces it over into the exhaust pipe of and into the other cylinder, which causes a back or counter pressure of 5 pounds during the period of exhaust, rising to 8 pounds just before the valve closes for exhaustion.

The line of release falls almost to the atmospheric line, which the exhaust line follows during a short period of the stroke, until the exhaust of the steam from the other cylinder takes place and forms the "hump" or curve in the line of exhaust.

This "hump" or rise in back pressure is not so detrimental to economy as would at first be supposed. The steam that is thus

forced over from the opposite cylinder is retained and compressed, and its energy given out during the succeeding stroke. On account of the insufficiency of lead and the large clearance space of this engine, this compression is not excessive; in fact the steam fails to reach boiler pressure by 15 pounds on the back end, and the steam still rises after the piston has begun to move.

There is a loss of power, however, from this "blowing over" of the steam—a loss that would be greater were the clearance space smaller.

The admission line in this card is not well maintained, the steam being very much wire-drawn, caused to a great extent by an insufficiency of lead, which ought to be in this notch at least one-quarter of an inch.

The expansion line falls away from the theoretical curve caused by condensation, and this water re-evaporating just before release raises the line up to the theoretical curve.

CARD No. 2.—Also taken in the second notch, but with the single nozzle having a diameter of $4\frac{3}{8}$ inches. As the steam in this case has greater facility to escape, from the larger nozzle, it is not forced over to such an extent as in No. 1, although the "hump" rises to nearly 5 pounds in the middle of the exhaust line.

The consumption of steam per indicated H. P. is here 4 per cent. less than in No. 1, and this with a greater amount of power produced. Again it must be remembered that Card No. 2 was taken a long time previous to No. 1, when the valve gear was in better order.

It will be seen that the distribution, from a larger amount of lead, an increase in boiler pressure, and speed is better, the steam line rising proportionally much higher, the admission line better maintained, and the expansion line more nearly approaching that drawn by theory. To these more favorable conditions must be attributed the more economical production of power and not to the greater size of the nozzle. The H. P. developed with similar boiler pressure and speed would, however, be much greater in No. 2 than in No. 1, and would in many cases prevent the lever from being dropped into the third notch and the engine run with a partly opened throttle, which, it is needless to state, would be very uneconomical.

DIAGRAMS TAKEN IN THE THIRD NOTCH.

CARD No. 3.—Taken with the single nozzle, 4 inches in diameter. Although this card is taken at a comparatively low speed, the steam that "blows over" from one cylinder to the other makes quite a curve or "hump" in the line of exhaust, rising more on the back than on the front end.

Lead is not sufficient to raise the steam line up to that of boiler pressure, and, as in the previous notch, the piston has commenced its stroke before the entering steam has reached its maximum height. Release is very good, but would be improved by an increase of lead.

CARD No. 4.—Taken with the single nozzle, $4\frac{3}{8}$ inches in diameter. The boiler pressure is 2 pounds less than in the previous card, but the speed is much greater. This increase of speed has caused an increase in the amount of steam "blown over," and this again has caused an increase in compression, which filling the clearance space, has raised the steam line up to or nearly up to that of boiler pressure.

Although we have from this cause a larger proportion of back to gross pressure, the work has been done with a trifle less steam per H. P. per hour. A superior result is here due to a higher speed, which would seem to indicate that cards taken at high speeds show the power to be obtained more economically than at lower speeds. This depends entirely on the arrangement of the details governing the distribution of the steam in the cylinder. If we were to reduce the clearance space and increase greatly the lead, the reverse would be the case. Exhaustion would then be less perfect (from a decrease in the size of the steam ports), the amount "blown over," if not greater, would, added to the imperfect exhaust, greatly increase compression, and not only would there be a loss of power by back pressure, but the consumption of steam per indicated H. P. would be greater.

CARD No. 5.—Taken with the single nozzle, $4\frac{5}{8}$ inches in diameter, is decidedly superior to the previous ones. The rise or curve in the exhaust line is not so great, owing to the large size of the nozzle. The steam line rises much nearer the boiler pressure, and the other lines of the diagram are much improved. This result is attributable to a higher boiler pressure. I find from a comparison of a number

of diagrams that where a high boiler pressure is used, the initial pressure in the cylinder is also higher in proportion. This effect of high pressure is noticed in my last communication.

The consumption of water per indicated H. P. is 2 per cent. less in this than in Card No. 4, attributable to the use of a higher boiler pressure and to the smaller proportion of back pressure.

CARD No. 6.—Taken with the compound nozzle, the double nozzles being each 4½ inches and the single nozzle 4 inches in diameter. This is by no means a good card, back pressure being from the "blowing over" very great. The steam line fails by a great deal to reach boiler pressure, and the steam during admission is considerably wire-drawn, attributable to insufficient lead and high speed.

CARD No. 7.—Compound nozzle, the three nozzles being each 4½ inches in diameter. By increasing the single nozzle from 4 to 4½ inches in diameter, we have effected a great improvement in the exhaust.

The escaping steam meets with little obstruction, and there is scarcely any "hump" formed. The power obtained in this notch with a given boiler pressure and speed is greatly increased, and this with a decreased consumption of steam per H. P.

The exhaust line in this card compares very favorably with that of No. 5, the latter being taken with a larger nozzle and at a much lower speed. The cost of producing the power is a trifle greater in No. 7 than in No. 5, owing to the inferior condition of the valve gear.

CARD No. 8.—Taken with the compound nozzle, the double nozzles being each 4½ inches and the single nozzle 5 inches in diameter. Here the steam after leaving the double nozzles may be said to meet with no obstruction and should not be forced over into the other cylinder, and this is substantially the case as shown in the figures. The line of release does not fall to that of the atmosphere, and the exhaust line runs parallel with it, indicating a back pressure of 2½ pounds.

This, whether it be steam left in the cylinder or steam from the opposite one, is certainly caused by steam filling both exhaust pipes, and preventing the falling of the exhaust line to that of the atmosphere before the exhaust port is closed.

Owing to the lower boiler pressure and speed, the power in this case is obtained at a greater cost than in No. 7.

DIAGRAMS TAKEN IN THE FOURTH NOTCH.

CARD No. 9.—Low double nozzle, each 3½ inches in diameter. Shows a very good distribution of the steam. This card would, like those in the third notch, be improved by an increase of lead. It is evident by a glance at this card that the exhaust pipes are not in communication. The line of exhaust shows a back pressure in the cylinder of 1½ pounds. I am not sure whether this is vapor left in the cylinder and exhaust passages or in the pipes connecting the indicator with the cylinder or a slight leak in the indicator cocks. Perhaps we will not go wrong in attributing it to all of these possible causes.

CARD No. 10.—Single nozzle, 4 inches in diameter. The effect of the communication between the exhaust pipes is very evident in this card, and is more pronounced than in the third notch. The line of release does not fall to the atmospheric line by several pounds, and this with a comparatively low boiler pressure and speed.

CARD No. 11.—Single nozzle, 4⅝ inches in diameter. This card is taken at a high speed and boiler pressure, and consequently the rise in the exhaust line is considerable, showing in the middle a back pressure of 7 pounds.

Even though we have in this card a greater proportion of back to gross pressure, the power is obtained with the same consumption of steam per H. P. as in No. 10, the result of a higher boiler pressure and speed.

CARD No. 12.—Single nozzle, 4⅝ inches in diameter. This card, taken with a high boiler pressure, shows a very good distribution of steam. The presence of exhaust steam from the other cylinder is indicated by the curved exhaust line.

CARD No. 13.—Compound nozzle, 4½ inches double and 4 inches single. This nozzle gives a very inferior distribution, back pressure being very great, which detracts considerably from the power developed in this notch. Insufficient lead is very apparent, especially on the back end. Speed has in this case greatly influenced the quality of the exhaust, owing to the small size of the single nozzle. The line of release does not fall well, and the exhaust line remains above the atmospheric line, showing a back pressure of nearly 5 pounds

for a considerable portion of the stroke, when the steam from the other cylinder raises it to 8 pounds.

Comparing this card with No. 6, where the pressure of steam is 12 pounds less at the point of release, it will be noticed that the exhaust line rises about the same height in each card from the "blow over," although we might expect it to be higher in No. 13, considering the more imperfect exhaust.

CARD No. 14.—Compound nozzle, 4½ inches double and 4½ inches single. This nozzle gives a much better card than the previous one. They are taken under similar, if not exactly the same, condition of speed and boiler pressure, and at nearly the same time.

The exhaust line is considerably improved, and the line of release falls much closer to that of the atmosphere and the proportion of back to gross pressure 5 per cent. less. The H. P. developed, even with a boiler pressure of one pound less (equal to 7 H. P.), is greater, and the consumption of steam per indicated H. P. per hour is decreased 4 per cent. All these improvements are solely due to the increase in size of the single nozzle.

CARD No. 15.—Compound nozzle, the double nozzles being each 3½ inches and the single nozzle 4½ inches in diameter. The exhaust line in this case shows no "hump," but it is kept above the atmospheric line by vapor or steam in the exhaust passages.

The engine in this case is really working with double exhaust nozzles as in No. 9, the single nozzle of 4½ inches being too large to materially affect the quality of the exhaust.

The consumption of steam per H. P. is about 3 per cent. greater than in No. 9, owing entirely to the smaller amount of lead from wear of valve gear, both cards being taken under similar conditions.

CARD No. 16.—Compound nozzle, 3½ inches double and 6 inches single. By enlarging the single nozzle to 6 inches we decrease the amount of vapor left in the exhaust passages, and cause the exhaust line more nearly to approach the atmospheric line; but it must be remembered that the speed is somewhat less. Compression is here much reduced, causing the proportion of back to gross pressure to fall to 6 per cent., and further, we have the work performed with less steam per H. P., due in great part to the higher boiler and smaller amount of back pressure.

CARD No. 17.—Compound nozzle, 4½ inches double and 4¾ inches

single. This is an example where an increase of speed increases the H. P. with economy. The work is done with the same consumption of steam per H. P. as in No. 16, where the boiler pressure is very much greater, to be attributed to superior exhaustion in proportion to the speed and increased compression, which has raised the steam line proportionally higher.

CARD No. 18.—Compound nozzle, $4\frac{1}{2}$ inches double and 5 inches single. Through a decrease in speed we have an increase in the amount of steam used per H. P. amounting to nearly 5 per cent., although the single exhaust nozzle is much larger.

This effect of speed and high initial pressure must not be forgotten when comparing the results given by different nozzles. The advantages to be gained by speed and pressure depending on the size and arrangement of nozzle, being greater with the double and compound nozzles, with the exception of that where the single nozzle is only 4 inches in diameter.

DIAGRAMS TAKEN IN THE FIFTH NOTCH.

In this and the sixth notch the influence of the exhaust nozzle is much more marked than in the first four notches, and I would ask to be excused for necessary repetition, as all forms of nozzle affect similarly the distribution in each notch, the difference being only one of degree.

CARD No. 19.—Low double nozzles, each $3\frac{1}{2}$ inches in diameter. Is taken with a low boiler pressure, but at a high speed, over 28 miles an hour. The steam line rises very well, considering the low boiler pressure, but the line of release does not fall with sufficient rapidity to secure a good exhaust, and as a consequence the exhaust line indicates a back pressure of 4 pounds during the whole period of exhaust.

CARD No. 20.—High double nozzle, each $3\frac{5}{8}$ inches in diameter. This card is but little different from No. 19, and indicates the work performed with a trifle less steam per indicated H. P. per hour, to be attributed to a higher boiler pressure. The steam line rises well up to boiler pressure, and in the back end has been compressed somewhat higher. All the lines of the diagram are similar to those in No. 19, and the distribution with these nozzles may be considered the same.

Card No. 21.—Single nozzle, 4 inches in diameter. Here we have the well-known "hump" in the exhaust line, and though the boiler pressure is the same and the speed less than in No. 20, the proportion of back to gross pressure is almost double and the H. P. developed in proportion to speed very much less. Again, this smaller amount of power is obtained with an increased expenditure of steam amounting to 5 per cent. per indicated H. P. per hour. The large amount of back pressure has much increased compression, especially on the back end, where the steam line rises as it would with a greater amount of lead.

A 4 inch single nozzle is clearly "not the thing" for the development of the maximum power in this notch, and this card tells, most eloquently, the necessity of enlarging it.

Card No. 22.—Taken with a larger nozzle, shows a reduction in back pressure in proportion to the higher boiler pressure and speed. The back pressure is, however, still very great.

The lower expenditure of 3 per cent. in steam per H. P. must be attributed to the higher boiler pressure and speed, and not to the increase in the size of the nozzle.

Card No. 23.—By a further increase in the size of the nozzle we obtain much better results. With a much higher boiler pressure and a somewhat higher speed the back pressure is considerably less than in No. 21, and the power is obtained with 4 per cent. less steam per H. P.

This distribution is inferior to that of Nos. 19 and 20. The principal point of inferiority being the greater amount of back pressure. The consumption of steam per H. P. is similar, but the boiler pressure in No. 23 is very much higher.

Card No. 24.—Compound nozzle, 4½ inches double and 4 inches single. This may really be called a 4 inch nozzle, yet it gives a somewhat superior exhaust to the 4 inch single nozzle as shown in No. 21. With a higher initial pressure, and consequent higher pressure at the point of release, that line approaches much nearer to the atmospheric line and the back pressure is much less. The consumption of steam per H. P. is the same, although the lead in No. 24 is much less than in No. 21.

Card No. 25.—Taken with the compound nozzle, each of the three nozzles being 4½ inches in diameter. A very good distribu-

tion, but the boiler pressure is low, and the steam line does not rise well up to that of boiler pressure, owing to insufficient lead. From these causes this card does not show the work to be done with less steam, though the back pressure, notwithstanding the greater speed, is less than in No. 23.

CARD No. 26.—Compound nozzle, $3\frac{1}{2}$ inches double and $4\frac{1}{2}$ inches single. May be considered exactly similar to No. 20, with a smaller amount of lead, which causes the production of power to be more expensive.

CARD No. 27.—With the single nozzle increased to 6 inches gives a very good card. The speed is comparatively very slow—17 miles an hour. The boiler pressure is, however, very high, and gives an economical production of power. This high pressure and the low speed brings the steam line up to boiler pressure on the back end, but not until the piston has commenced its stroke, showing an insufficiency of lead. This card, from its unusually high pressure and low, speed is not comparable with others as an example of the effect of the nozzle on the distribution of the steam in the cylinder.

CARD No. 28.—Compound nozzle, $4\frac{1}{2}$ inches double and $4\frac{3}{4}$ inches single. This card is comparable with No. 23; and though the back pressure is somewhat less the power is not obtained with greater economy, the lead being greater in No. 23.

CARD No. 29.—The single nozzle being enlarged to 5 inches in diameter. Back pressure is considerably reduced and the power obtained with a slight economy.

The release and exhaust lines are much superior to those on Card No. 28; and, in fact, are superior to similar lines in all other cards and show an almost perfect exhaust.

That the line of release does not fall to the atmospheric line is not due to the nozzle but to the friction of the steam in passing through the steam port.

This card, compared with No. 28, proves that in the compound nozzle the single nozzle must be much larger than the double nozzles to obtain a perfect exhaust. This is also proved where the double nozzles are each $3\frac{1}{2}$ inches in diameter and the single nozzle increased from $4\frac{1}{2}$ to 6 inches.

If, in this card, lead were greater the consumption of steam per

H. P. would also be reduced and the line of release, and possibly that of exhaust, improved.

Taken altogether this card is very satisfactory; the boiler pressure being high and the speed 21 miles an hour, which is a very high rate for a freight engine working in this notch.

We can not look for any appreciable economy by improving exhaustion, but a considerable improvement could be effected by bringing the steam line well up to that of boiler pressure before the commencement of the stroke, easily accomplished by an increase of lead and by maintaining this pressure during the period of admission, which could only be done by using superheated steam and securing an early and large opening of port.

By obtaining by these means a maximum amount of power in this notch, from a given boiler pressure and speed, we avoid the necessity of dropping the lever into the sixth notch, which is a very expensive one—the power being obtained with a very much higher consumption of steam per indicated H. P.

DIAGRAMS TAKEN IN THE SIXTH NOTCH.

CARDS NOS. 30 AND 31.—Are taken with the single nozzle $4\frac{5}{8}$ inches in diameter.

No. 31 represents the work done by the locomotive overcoming a gradient of 20 feet to the mile and about $1\frac{1}{4}$ miles long.

The train consists of 45 loaded eight-wheeled American box cars, weighing about 800 gross tons—cars and freight. With such a train this grade must be taken with a smart run, which in this card, taken as "she strikes the grade," is about 26 miles an hour.

The H. P. developed is 784—the back pressure being very great, amounting to nearly 95 H. P., is certainly very excessive. The cost of producing this power is a trifle less than in No. 30, which we must attribute to the higher pressure, if not to speed, which is rather high to prove economical in this notch and to the superior form of the exhaust line. It will be noticed that the exhaust line falls to within 6 pounds of the atmospheric line in No. 31, when the exhaust steam from the other cylinder is "blown over" and raises it to 14 pounds in the middle, and it again falls to 11 pounds at the point where the valve closes the exhaust. This volume of steam, 11

pounds in pressure, is stored up in the clearance space and gives out its energy during the succeeding stroke.

In No. 30, however, the case is different; the exhaust line falls to within 2 pounds of the atmospheric line and is then raised by the steam, from the opposite cylinder, to a height of 11 pounds in the middle, and it then falls to 3½ pounds at the point of compression. This is a bad phase of the "blow over," the steam exerting a prejudicial back pressure and escaping before compression commences, an effect due to low speed.

In No. 31 very little of the steam blown over is lost, the higher speed not giving it time to get away again before the valves closes the communication with the atmosphere; the steam "blown over" only detracting, by its back pressure, from the power furnished in this notch.

It would even appear economical to have a "blow over," where the whole amount is saved by compression, because it keeps the surfaces of the cylinder and piston at a higher temperature before live steam from the boiler is admitted, preventing a loss from condensation, and, although cards with this "blow over" do not show a superior economical production of power, there is no doubt that this mitigates the evil resulting from the greater back pressure.

Card No. 32.—Compound nozzle, 4½ inches double and 4 inches single. This card proves the truth of the foregoing remarks. Here we have a much higher proportion of back pressure, which at the point of compression is 14 pounds.

This enormous amount of back pressure detracts considerably from the H. P. that should be exerted in this notch; but yet the cost of obtaining it is only 5 per cent. greater than in No. 31, and this must be attributed almost entirely to a much lower boiler pressure and a smaller amount of lead. This insufficiency of lead is very clearly shown in the back end, where the piston has traveled some distance before the steam has reached its maximum height.

Card No. 33.—Compound nozzle; each of the three nozzles being 4½ inches in diameter. In this card the "blow over" is still visible; but notwithstanding its lower boiler pressure, speed, and lead, it compares favorably with No. 31 (speed, when the exhaust is good, decreasing the steam used per H. P.), in regard to consumption of steam per H. P.

Card No. 34.—Compound nozzle, 3½ inches double and 4½ inches single. Comparing this card with No. 26, taken in the fifth notch, under similar conditions of speed, boiler pressure, and form of nozzle, the advantage of working steam expansively is well illustrated. The H. P. in No. 34 is 574, and in No. 26 is 522, a difference of 52 H. P., which could have been developed in No. 26 with an additional boiler pressure of about 8 pounds, and the consumption of steam reduced from 23.7 pounds to about 23.25 pounds per indicated H. P., which is over 10 per cent. less than the consumption shown in No. 34.

The release pressure would be much less in the fifth notch and the action of the blast much milder, increasing the evaporation of water per pound of coal and lowering the vacuum in the smoke box, which means less tendency to throw burning cinders out of the slack.

Card No. 35.—Compound nozzle, 4½ inches double and 4¾ inches single. Is a very good card, showing a good release and a slight curve in the exhaust line.

Card No. 36.—With the single nozzle increased to 5 inches, is a further improvement. It will be seen that the line of release does not fall to the atmospheric line in any of the cards in this notch, and that the exhaust line falls to its minimum only after the piston has traveled a considerable portion of its stroke; and, further, that the line of release is not greatly improved by a considerable augmentation in the size of the exhaust nozzles, as, for instance, in the compound nozzles, where the 3½ inch double and 4½ inch single, and 4½ inch double and 5 inch single, are used.

DIAGRAMS IN THE SEVENTH NOTCH.

Card No. 37.—4⅝ inch single nozzle. This card, taken with a high boiler pressure and at a speed of 14 miles an hour, has a very inferior form of exhaust line, the steam "blown over" raising it up to 12 pounds, and most of this escaping before the exhaust port is closed, leaves a volume of steam only 5 pounds in pressure to be stored up in the clearance space.

An error has been made in tracing the admission line on the back end of this figure. There were several of these lines parallel with one another, and the upper one, being the most clearly defined, was traced. Some delay has taken place between the time of taking these

two figures, and the pressure of steam has risen in the boiler. Since the power was calculated with this line it has not been altered.

Card No. 38.—Compound nozzle, 4½ inches double and 5 inches single. Has a very superior exhaust line to that of No. 37, although it does not so soon reach its minimum height above the atmospheric line, caused by high speed, which greatly influences the quality of the exhaust in this notch. The steam line does not rise to boiler pressure from insufficiency of lead, and to the lower initial pressure and higher speed must be attributed the slightly increased consumption of steam per indicated H. P.

EIGHTH NOTCH.

Card No. 39.—Shows the distribution in the eighth notch with the single nozzle, 4⅝ inches in diameter. There is a back pressure of 5.2 pounds, caused almost entirely by the steam "blowing over" from the other cylinder. This is "pure loss," the steam escaping long before compression begins.

The fall in the admission line is no doubt caused by the valve closing the port. The steam line indicates that the engine would be improved with a greater amount of lead.

NINTH NOTCH OR FULL GEAR.

Card No. 40.—The same remarks apply to this as to the last card. The exhaust line has been raised in this case to a height of 17 pounds above the atmospheric line, by the exhaust steam from the opposite cylinder, causing an average back pressure of 5.2 pounds during the stroke.

The fall of the admission line for a short portion of the stroke is evidently caused by the valve moving across the edge of the port, which for an instant checks the flow of the steam. The consumption of steam per indicated H. P. per hour is 33.7 pounds in this notch. A similar amount of power is developed in Card No. 1 with a consumption per H. P. of 21.16 pounds of steam, or 37 per cent. less.

INDICATOR DIAGRAMS.

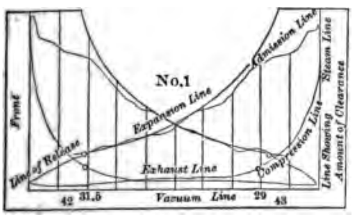
Experiments with Exhaust Nozzles, No. 4 Roger Mogul Freight, 16½ by 24 inch Cylinders, Talca-Talcahuano & Angol Railroad.

BY JOHN E. MARTIN.

Richard's indicator; same spring used in all experiments; same method used in calculating the cards, as explained in my report on tests of passenger locomotives, Eleventh Annual Report; scale of indicator, 48 pounds per inch (150 pounds spring).

Dimensions given in report of Master Mechanics' Association for Tenth Annual Convention, and in sheet of experiments inclosed.

The lead and cut-off noted on each diagram was taken in December, 1878, and is therefore too little for cards taken some time previous to that date.

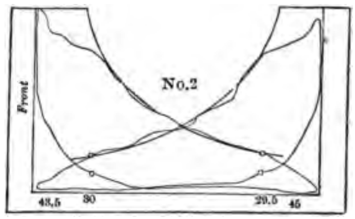


NOVEMBER 1, 1878.—Compound nozzle 4½ inches double and 4 inches single, 2d notch, not throttled, boiler pressure 138 lbs., revolutions 144 per minute, water ¾ glass, vacuum 1½ inches, cut off 7½ inches, lead 3-16 inch.

Mean of the two ends—H. P. 340.3, water per H. P. 21.16.

FRONT END—Water used per minute 120.13 lbs., water used per hour 7210 lbs., water used per indicated H. P. per hour 29.9 lbs., gross pressure 58.5 lbs., back pressure 12.2 lbs., mean pressure 46.3 lbs., H. P. 345.46, proportion of back to gross pressure 21 per cent.

BACK END—Water used per minute 119.66 lbs., water used per hour 7180 lbs., water used per indicated H. P. per hour 21.42 lbs., gross pressure 55.7 lbs., back pressure 10.8 lbs., mean pressure 44.9 lbs, H. P. 335.13, proportion of back to gross pressure 19 per cent.

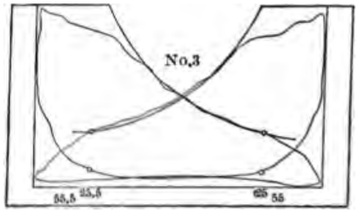


FEBRUARY 8, 1877.—4⅜ inch single nozzle, 2d notch, not throttled, boiler pressure 143 lbs., revolutions 160 per minute, water ¾ glass, vacuum 2¼ inches, cut off 7½ inches, lead 3-16 inch.

Mean of the two ends—H. P. 416.35, water per indicated H. P. 20.26 lbs.

FRONT END—Water used per minute 143.31 lbs., water used per hour 8599 lbs., water used per indicated H. P. per hour 20.2 lbs., gross pressure 62.3 lbs., back pressure 11.0 lbs., mean pressure 51.3 lbs., H. P. 425.5, proportion of back to gross pressure 18 per cent.

BACK END—Water used per minute 137.9 lbs., water used per hour 8274 lbs., water used per indicated H. P. per hour 20.32 lbs., gross pressure 58.7 lbs., back pressure 9.6 lbs., mean pressure 49.1 lbs., H. P. 407.2, proportion of back to gross pressure 17 per cent.

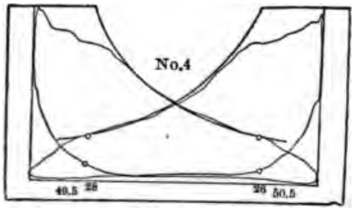


FEBRUARY 6, 1877.—4 inch single nozzle, 3d notch, not throttled, boiler pressure 139 lbs, revolutions 116 per minute, water full glass, vacuum 3 inches, cut off 9⅛ inches, lead 3-16 inch.

Mean of the two ends—H. P. 388, water per H. P. 21.12 lbs.

FRONT END—Water used per minute 135.77 lbs., water used per hour 8146 lbs., water used per indicated H. P. per hour 20.87 lbs., gross pressure 74.3 lbs., back pressure 9.4 lbs., mean pressure 64.9 lbs., H. P. 390.2, proportion of back to gross pressure 13 per cent.

BACK END—Water used per minute 137.58 lbs., water used per hour 8255 lbs., water used per indicated H. P. per hour 21.38 lbs., gross pressure 73.5 lbs., back pressure 9.03 lbs., mean pressure 64.2 lbs., H. P. 386, proportion of back to gross pressure 13 per cent.

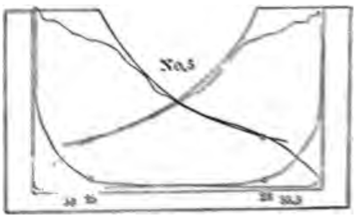


FEBRUARY 8, 1877.—4¾ inch single nozzle, 3d notch, not throttled, boiler pressure 137 lbs., revolutions 152 per minute, water ¼ glass, vacuum 2¾ inches, cut off 9⅛ inches, lead 3-16 inch.

Mean of the two ends—H. P. 449.6, water per H. P. 21.07 lbs.

FRONT END—Water used per minute 158.5 lbs., water used per hour 9510 lbs., water used per indicated H. P. per hour 20.84 lbs., gross pressure 68.4 lbs., back pressure 10.5 lbs., mean pressure 57.9 lbs., H. P. 456.3, proportion of back to gross pressure 15 per cent.

BACK END—Water used per minute 157.3 lbs., water used per hour 9438 lbs., water used per indicated H. P. per hour 21.07 lbs., gross pressure 65.7 lbs., back pressure 9.5 lbs., mean pressure 56.2 lbs., H. P. 442.9, proportion of back to gross pressure 15 per cent.

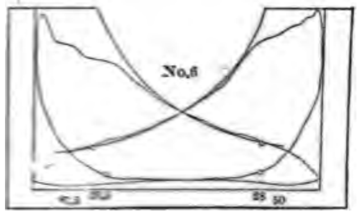


APRIL [illegible] 1878.—[illegible] inch single nozzle, 3d notch, not throttled, boiler pressure 140 lbs., revolutions 144 per minute, water [illegible] glass, vacuum [illegible] inches, cut off [illegible] inches, lead 3-16 inch.

Mean of the two ends—H. P. [illegible], water per indicated H. P. [illegible].

FRONT END—Water used per minute [illegible] lbs., water used per hour [illegible] lbs., water used per indicated H. P. per hour [illegible] lbs., gross pressure [illegible] lbs., back pressure [illegible] lbs., mean pressure [illegible] lbs., H. P. [illegible], proportion of back to gross pressure 11 per cent.

BACK END—Water used per minute [illegible] lbs., water used per hour [illegible] lbs., water used per indicated H. P. per hour [illegible] lbs., gross pressure [illegible] lbs., back pressure [illegible] lbs., mean pressure [illegible] lbs., H. P. [illegible], proportion of back to gross pressure [illegible] per cent.

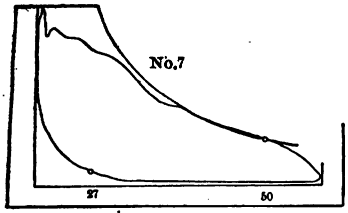


NOVEMBER 1, 1878.—Compound nozzle 4⅛ inches double and 4 inches single, 3d notch, not throttled, boiler pressure 139 lbs., revolutions 164 per min., water ½ glass, vacuum 2½ inches, cut off 9⅛ inches, lead 3-16 inch.

Mean of the two ends—H. P. 461.5, water 21.55 lbs.

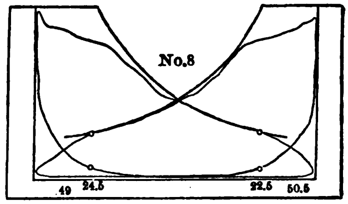
FRONT END—Water used per minute 165.77 lbs., water used per hour 9946 lbs., water used per indicated H. P. per hour 21.55 lbs., gross pressure 66.9 lbs., back pressure 12.6 lbs., mean pressure 54.3 lbs., H. P. 461.5, proportion of back to gross pressure 19 per cent.

BACK END—Water used per minute 159.1 lbs., water used per hour 9546 lbs., water used per indicated H. P. per hour 21.77 lbs., gross pressure 62.7 lbs., back pressure 11.1 lbs., mean pressure 51.6 lbs., H. P. 438.6, proportion of back to gross pressure 18 per cent.



November 29, 1878.—Compound nozzle, 4¼ inches double and 4½ inches single, 3d notch, not throttled, boiler pressure 139 lbs., revolutions 144 per minute, water ½ glass, cut off 9⅛ inches, lead 3-16 inch.

Front End—Water used per minute 149.75 lbs., water used per hour 8985 lbs., water used per indicated H. P. per hour 20.9 lbs., gross pressure 66.7 lbs., back pressure 9.1 lbs., mean pressure 57.6 lbs., H. P. 430, proportion of back to gross pressure 14 per cent.

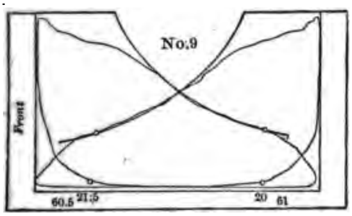


December 25, 1878.—Compound nozzle, 4½ inches double and 5 inches single, 3d notch, not throttled, boiler pressure 133 lbs., revolutions 136 per minute, water ½ glass, vacuum 1¾ inches, cut off 9⅛ inches, lead 3-16 inch.

Mean of the two ends—H. P. 416, water per H. P. 21.3 lbs.

Front End—Water used per minute 145.74 lbs., water used per hour 9144 lbs., water used per indicated H. P. per hour 21.83 lbs., gross pressure 67.3 lbs., back pressure 7.9 lbs., mean pressure 59.4 lbs., H. P. 418.8, proportion of back to gross pressure 12 per cent.

Back End—Water used per minute 143 lbs., water used per hour 8580 lbs., water used per indicated H. P. per hour 20.77 lbs., gross pressure, 65.1 lbs., back pressure 6.5 lbs., mean pressure 58.6 lbs., H. P. 413.1, proportion of back to gross pressure 10 per cent.

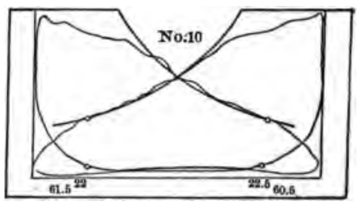


November 23, 1876.—3½ inches, low double nozzles, 4th notch, not throttled, boiler pressure 138 lbs., revolutions 132 per minute, water ½ glass, vacuum 4 inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 502, water per H. P. 21.2 lbs.

Front End—Water used per minute 177.34 lbs., water used per hour 10640 lbs., water used per indicated H. P. per hour 21.1 lbs., gross pressure 80.4 lbs., back pressure 6.7 lbs., mean pressure 73.7 lbs., H. P. 504.3, proportion of back to gross pressure 8 per cent.

Back End—Water used per minute 177.41 lbs., water used per hour 10645 lbs., water used per indicated H. P. per hour 21.3 lbs., gross pressure 78.7 lbs., back pressure 5.7 lbs., mean pressure 73.0 lbs., H. P. 500, proportion of back to gross pressure 7 per cent.

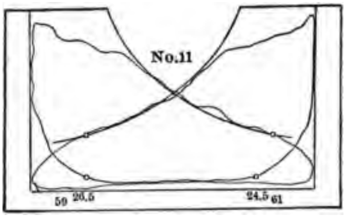


February 6, 1877.—4 inch single nozzle, 4th notch, not throttled, boiler pressure 130 lbs., revolutions 116 per minute, water ½ glass, vacuum 4 inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 417.8, water per H. P. 22.28.

Front End—Water used per minute 154 lbs., water used per hour 9240 lbs., water used per indicated H. P. per hour 21.96 lbs., gross pressure 78.4 lbs., back pressure 8.4 lbs., mean pressure 70.0, H. P. 420.8, proportion of back to gross pressure 11 per cent.

Back End—Water used per minute 156.2 lbs., water used per hour 9372 lbs., water used per indicated H. P. per hour 22.6 lbs., gross pressure 77.7 lbs., back pressure 8.7 lbs., mean pressure 69.0 lbs., H. P. 414.8, proportion of back to gross pressure 11 per cent.

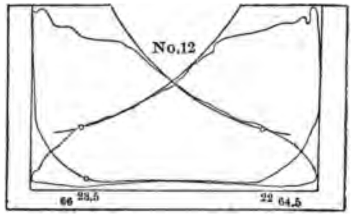


FEBRUARY 8, 1877.—4⅜ inch single nozzle, 4th notch, not throttled, boiler pressure 140 lbs., revolutions 160 per minute, water ¼ glass, vacuum 4 inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 557.5, water per H. P. 22.21 lbs.

FRONT END—Water used per minute 208.45 lbs., water used per hour 12507 lbs., water used per indicated H. P. per hour 22.18 lbs., gross pressure 79.7 lbs., back pressure 11.7 lbs., mean pressure 68.0 lbs., H. P. 564, proportion of back to gross pressure 15 per cent.

BACK END—Water used per minute 204.3 lbs., water used per hour 12258 lbs., water used per indicated H. P. per hour 22¼ lbs., gross pressure 76.6 lbs., back pressure 10.2 lbs., mean pressure 66.4 lbs., H. P. 551, proportion of back to gross pressure 13 per cent.

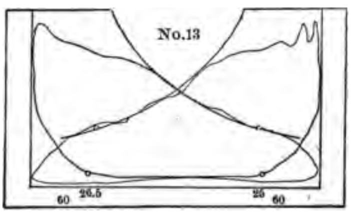


APRIL 29, 1878.—4⅝ inch single nozzle, 4th notch, not throttled, boiler pressure 143 lbs., revolutions 136 per minute, water full glass, vacuum 3½ inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 537.5, water per H. P. 21.8 lbs.

FRONT END—Water used per minute 193.66 lbs., water used per hour 11620 lbs., water used per indicated H. P. per hour 21.8 lbs., gross pressure 84.5 lbs., back pressure 8.9 lbs , mean pressure 75.6 lbs., H. P. 533, proportion of back to gross pressure 10 per cent.

BACK END—Water used per minute 196.76 lbs., water used per hour 11806 lbs., water used per indicated H. P. per hour 21.78 lbs., gross pressure 84.7 lbs., back pressure 7.8 lbs., mean pressure 76.9 lbs., H. P. 542, proportion of back to gross pressure 9 per cent.

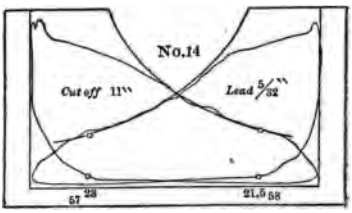


NOVEMBER 1, 1878.—Compound nozzle, 4½ inches double and 4 inches single, 4th notch, not throttled, boiler pressure 138 lbs., revolutions 148 per minute, water ¼ glass, vacuum 3 inches, cut off 11 inches, lead 5-32 nch.

Mean of the two ends—H. P. 502, water 22.74 lbs.

FRONT END—Water used per minute 189.4 lbs., water used per hour 11364 lbs., water used per indicated H. P. per hour 22.48 lbs., gross pressure 77.2 lbs., back pressure 12.3 lbs., mean pressure 65.9 lbs., H. P. 505.6, proportion of back to gross pressure 16 per cent.

BACK END—Water used per minute 191.2 lbs., water used per hour 11472 lbs., water used per indicated H. P. per hour 23 lbs., gross pressure 75.4 lbs., back pressure 10 4 lbs., mean pressure 65.0 lbs., H. P. 498.7, proportion of back to gross pressure 14 per cent.

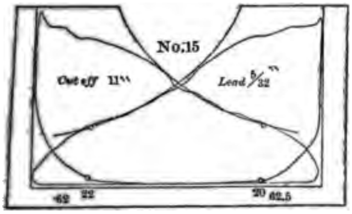


NOVEMBER 29, 1878.—Compound nozzle, 4½ inches double and 4¼ inches single, 4th notch, not throttled, boiler pressure 137 lbs., revolutions 148 per minute, water ½ glass, vacuum 2¾ inches.

Mean of the two ends—H. P. 510.2, water per H. P. 21.87 lbs.

FRONT END—Water used per minute 186 lbs., water used per hour 11160 lbs., water used per indicated H. P. per hour 21.87 lbs., gross pressure 75.0 lbs., back pressure 8.6 lbs., mean pressure 66.5 lbs., H. P. 510.2, proportion of back to gross pressure 11 per cent,

BACK END—Water used per minute 186 lbs., water used per hour, 11160 lbs., water used per indicated H. P. per hour, 21.87 lbs., gross pressure 73.5 lbs., back pressure 7.0 lbs., mean pressure 66.5 lbs., H. P. 510.2, proportion of back to gross pressure 10 per cent.

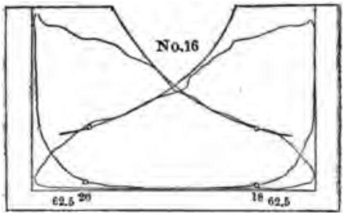


December 2, 1878.—Compound nozzle, 3⅝ inches double and 4½ inches single, 4th notch, not throttled, boiler pressure 139 lbs., revolutions 128 per minute, water ⅓ glass, vacuum 2½ inches.

Mean of the two ends—H. P. 486.4, water per H. P. 21.75 lbs.

Front End—Water used per minute 176 lbs., water used per hour 10560 lbs., water used per indicated H. P. per hour 21.83 lbs., gross pressure 80.3 lbs., back pressure 7.3 lbs., mean pressure 73.0 lbs., H. P. 483.8, proportion of back to gross pressure 9 per cent.

Back End—Water used per minute 176.6 lbs., water used per hour 10596 lbs., water used per indicated H. P. per hour 21.67 lbs., gross pressure 79.5 lbs., back pressure 5.7 lbs., mean pressure 73.8 lbs., H. P. 489, proportion of back to gross pressure 7 per cent.

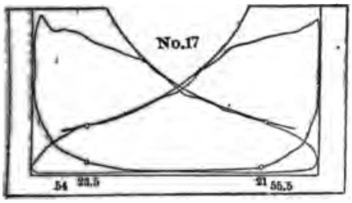


December 2, 1878.—Compound nozzle, 3½ inches double and 6 inches single, 4th notch, not throttled, boiler pressure 141 lbs., revolutions 120 per minute, water ½ glass, vacuum 3 inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 472, water per H. P. 21.3 lbs.

Front End—Water used per minute 167 lbs., water used per hour 10020 lbs., water used per indicated H. P. per hour 21.3 lbs., gross pressure 81.5 lbs., back pressure 5.9 lbs., mean pressure 75.6 lbs., H. P. 470.2, proportion of back to gross pressure 7 per cent.

Back End—Water used per minute 169 lbs., water used per hour 10140 lbs., water used per indicated H. P. per hour 21.4 lbs., gross pressure 80.4 lbs., back pressure 4.2 lbs., mean pressure 76.2 lbs., H. P. 474, proportion of back to gross pressure 5 per cent.

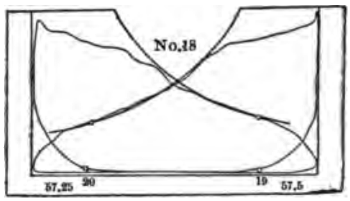


December 23, 1878.—Compound nozzle, 4⅝ inches double and 4¾ inches single, 4th notch, not throttled, boiler pressure 130 lbs., revolutions 160 per minute, water ½ glass, vacuum 2⅝ inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 529, water per H. P. 21.3 lbs.

Front End—Water used per minute 186.4 lbs., water used per hour 11185 lbs., water used per indicated H. P. per hour 21 lbs., gross pressure 72.1 lbs., back pressure 7.8 lbs., mean pressure 64.3 lbs., H. P. 533.3, proportion of back to gross pressure 11 per cent.

Back End—Water used per minute 189.3 lbs., water used per hour 11358 lbs., water used per indicated H. P. per hour 21.6 lbs., gross pressure 69.6 lbs., back pressure 6.3 lbs., mean pressure 63.3 lbs., H. P. 525, proportion of back to gross pressure 9 per cent.

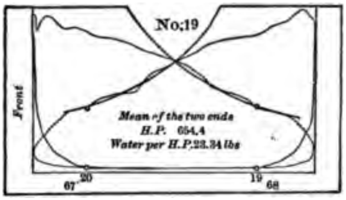


December 25, 1878.—Compound nozzle, 4½ inches double and 5 inches single, 4th notch, not throttled, boiler pressure 128 lbs., revolutions 124 per minute, water ½ glass, vacuum 2 inches, cut off 11 inches, lead 5-32 inch.

Mean of the two ends—H. P. 430, water per H. P. 22.25 lbs.

Front End—Water used per minute 159 lbs., water used per hour 9540 lbs., water used per indicated H. P. per hour 22.38 lbs., gross pressure 72.6 lbs., back pressure 6.3 lbs., mean pressure 66.3 lbs., H. P. 426.2, proportion of back to gross pressure 9 per cent.

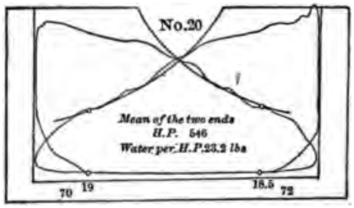
Back End—Water used per minute 160 lbs., water used per hour 9600 lbs., water used per indicated H. P. per hour 22.12 lbs., gross pressure 72.6 lbs., back pressure 5.1 lbs., mean pressure 67.5 lbs., H. P. 433.9, proportion of back to gross pressure 7 per cent.



NOVEMBER 23, 1876.—3½ inch low double nozzles, 5th notch, not throttled, boiler pressure 130 lbs., revolutions 168 per minute, water ½ glass, vacuum 5 inches, cut off 13¼ inches, lead ⅛ inch full.

FRONT END—Water used per minute 255.8 lbs., water used per hour 15348 lbs., water used per indicated H. P. per hour 23.44 lbs., gross pressure 82.3 lbs., back pressure 7.1 lbs., mean pressure 75.2 lbs., H. P. 654.8, proportion of back to gross pressure 9 per cent.

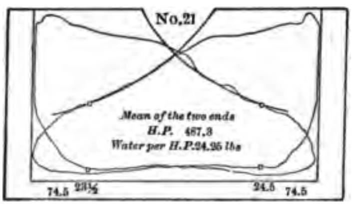
BACK END—Water used per minute 253.3 lbs., water used per hour 15198 lbs., water used per indicated H. P. per hour 23.24 lbs., gross pressure 81.7 lbs., back pressure 6.6 lbs., mean pressure 75.1 lbs. H. P. 654, proportion of back to gross pressure 8 per cent.



OCTOBER 7, 1876.—3⅜ inch high double nozzles, 5th notch, not throttled, boiler pressure 133 lbs., revolutions 132 per minute, water ¾ glass, vacuum 4½ inches, cut off 13¼ inches, lead ⅛ inch full.

FRONT END—Water used per minute 214.3 lbs., water used per hour 12858 lbs., water used per indicated H. P. per hour 23.6 lbs., gross pressure 86.7 lbs., back pressure 7.0 lbs., mean pressure 79.7 lbs., H. P. 545.3, proportion of back to gross pressure 8 per cent.

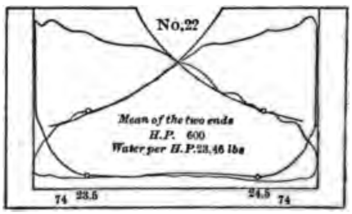
BACK END—Water used per minute 208.7 lbs., water used per hour 12522 lbs., water used per indicated H. P. per hour 22.9 lbs., gross pressure 86.0 lbs., back pressure 6.1 lbs., mean pressure 79.9 lbs., H. P. 546.7, proportion of back to gross pressure 7 per cent.



FEBRUARY 6, 1877.—4 inch single nozzle, 5th notch, not throttled, boiler pressure 133 lbs., revolutions 120 per minute, water ½ glass, cut off 13¼ inches, lead ⅛ inch full.

FRONT END—Water used per minute 197.4 lbs., water used per hour 11844 lbs., water used per indicated H. P. per hour 24.2 lbs., gross pressure 90.8 lbs., back pressure 12.1 lbs., mean pressure 78.7 lbs., H. P. 489.5, proportion of back to gross pressure 13 per cent.

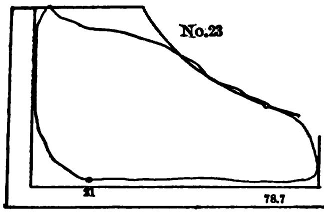
BACK END—Water used per minute 196.4 lbs., water used per hour, 11784 lbs., water used per indicated H. P. per hour 24.3 lbs., gross pressure 89.9 lbs., back pressure 11.9 lbs., mean pressure 78.0 lbs., H. P. 485.2, proportion of back to gross pressure 13 per cent.



FEBRUARY 8, 1877.—4⅜ inch single nozzle, 5th notch, not throttled, boiler pressure 140 lbs., revolutions 144 per minute, water ½ glass, cut off 13¼ inches, lead ⅛ inch full.

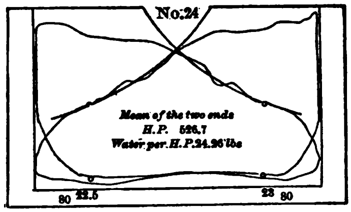
FRONT END—Water used per minute 235.2 lbs., water used per hour 14112 lbs., water used per indicated H. P. per hour 23.26 lbs., gross pressure 91.9 lbs., back pressure 10.6 lbs., mean pressure 81.3 lbs., H. P. 606.8, proportion of back to gross pressure 11 per cent.

BACK END—Water used per minute 234 lbs., water used per hour 14040 lbs., water used per indicated H. P. per hour 23.66 lbs., gross pressure 90.1 lbs., back pressure 10.6 lbs., mean pressure 79.5 lbs., H. P. 593.4 lbs., proportion of back to gross pressure 11 per cent.



April 29, 1878.—4⅝ inch single nozzle, 5th notch, not throttled, boiler pressure 141 lbs., revolutions 126 per minute, water full glass, vacuum 4½ inches, cut off 13¾ inches, lead ⅛ inch full.

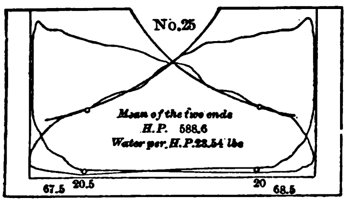
Front End—Water used per minute 226 lbs., water used per hour 13560 lbs., water used per indicated H. P. per hour, 23.26 lbs., gross pressure 96.5 lbs,, back pressure 8.7 lbs., mean pressure 87.8 lbs., H. P. 583, proportion of back to gross pressure 9 per cent.



November 1, 1878.—Compound nozzle, 4½ inches double and 4 inches single, 5th notch, not throttled, boiler pressure 140 lbs., revolutions 120 per minute, water ¼ glass, vacuum 4 inches, cut off 13¾ inches, lead ⅛ inch full.

Front End—Water used per minute 213.8 lbs., water used per hour 12828 lbs., water used per indicated H. P. per hour 24.67 lbs., gross pressure 94.8 lbs., back pressure 11.2 lbs., mean pressure 83.6 lbs., H. P. 520, proportion of back to gross pressure 12 per cent.

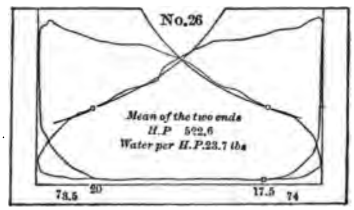
Back End—Water used per minute 212.9 lbs., water used per hour 12774 lbs., water used per indicated H. P. per hour 23.85 lbs., gross pressure 95.7 lbs., back pressure 9.6 lbs., mean pressure 86.1 lbs., H. P. 535.5, proportion of back to gross pressure 10 per cent.



November 29, 1878.—Compound nozzle, 4½ inches double and 4½ inches single, 5th notch, not throttled, boiler pressure 130 lbs., revolutions 152 per minute, water full glass, vacuum 3¾ inches, cut off 13¾ inches, lead ⅛ inch full.

Front End—Water used per minute 232.6 lbs., water used per hour 13956 lbs., water used per indicated H. P. per hour 23.64 lbs., gross pressure 82.4 lbs., back pressure 7.6 lbs., mean pressure 74.8 lbs., H. P. 589.4, proportion of back to gross pressure 9 per cent.

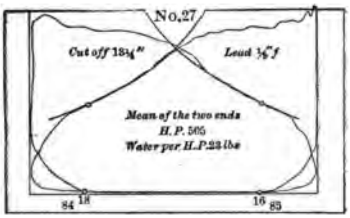
Back End—Water used per minute 229.7 lbs., water used per hour 13782 lbs., water used per indicated H. P. per hour 23.44 lbs., gross pressure 81.1 lbs., back pressure 6.5 lbs., mean pressure 74.6 lbs., H. P. 587.8, proportion of back to gross pressure 8 per cent.

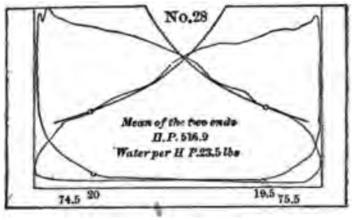


December 2, 1878.—Compound nozzle, 3½ inches double and 4½ inches single, 5th notch, not throttled, boiler pressure 135 lbs., revolutions 124 per minute, water ½ glass, vacuum 4 inches, cut off 13¾ inches, lead ⅛ inch full.

Front End—Water used per minute 206 lbs., water used per hour 12360 lbs., water used per indicated H. P. per hour 23.83 lbs., gross pressure 88.2 lbs., back pressure 7.5 lbs., mean pressure 80.7 lbs., H. P. 518.7, proportion of back to gross pressure 8 per cent.

Back End—Water used per minute 207.2 lbs., water used per hour 12432 lbs., water used per indicated H. P. per hour 23.6 lbs., gross pressure 87.7 lbs., back pressure 5.8 lbs., mean pressure 81.9 lbs., H. P. 526.5, proportion of back to gross pressure 7 per cent.





DECEMBER 2, 1878.—Compound nozzle, 3½ inches double and 6 inches single, 5th notch, not throttled, boiler pressure 143 lbs., revolutions 100 per minute, water full glass, vacuum 4 inches.

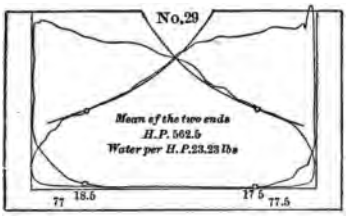
FRONT END—Water used per minute 194.5 lbs., water used per hour 11670 lbs., water used per indicated H. P. per hour 23.1 lbs., gross pressure 101.2 lbs., back pressure 4.1 lbs., mean pressure 97.1 lbs., H. P. 505, proportion of back to gross pressure 4 per cent.

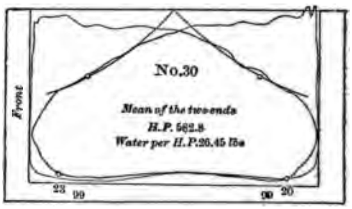
BACK END—Water used per minute 192.8 lbs., water used per hour 11560 lbs., water used per indicated H. P. per hour 22.9 lbs., gross pressure 100.2 lbs., back pressure 3.1 lbs., mean pressure 97.1 lbs., H. P. 505, proportion of back to gross pressure 3 per cent.

DECEMBER 23, 1878.—Compound nozzle, 4½ inches double and 4¾ inches single, 5th notch, not throttled, boiler pressure 140 lbs., revolutions 120 per minute, water ½ glass, vaccuum 4 inches, cut off 13¾ inches, lead ⅛ inch full.

FRONT END—Water used per minute 203.7 lbs., water used per hour 12223 lbs., water used per indicated H. P. per hour 23.42 lbs., gross pressure 91.4 lbs., back pressure 7.5 lbs., mean pressure 83.9 lbs., H. P. 521.9, proportion of back to gross pressure 8 per cent.

BACK END—Water used per minute 201.3 lbs., water used per hour 12078 lbs., water used per indicated H. P. per hour 23.6 lbs., gross pressure 89.6 lbs., back pressure 7.3 lbs., mean pressure 82.3 lbs., H. P. 511.9, proportion of back to gross pressure 8 per cent.





DECEMBER 25, 1878.—Compound nozzle, 4½ inches double and 5 inches single, 5th notch, not throttled, boiler pressure 138 lbs., revolutions 124 per minute, water ½ glass, vacuum 3 inches, cut off 13¾ inches, lead ⅛ inch full.

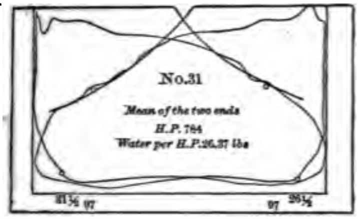
FRONT END—Water used per minute 218 lbs., water used per hour 13080 lbs., water used per indicated H. P. per hour 23.36 lbs., gross pressure 92.7 lbs., back pressure 5.6 lbs., mean pressure 87.1 lbs., H. P. 560, proportion of back to gross pressure 6 per cent.

BACK END—Water used per minute 217.5 lbs., water used per hour 13050 lbs., water used per indicated H. P. per hour 23.1 lbs., gross pressure 92.1 lbs., back pressure 4.2 lbs., mean pressure 87.9 lbs., H. P. 565, proportion of back to gross pressure 5 per cent.

APRIL 29, 1878.—4⅝ inch single nozzle, 6th notch, not throttled, boiler pressure 135 lbs., revolutions 112 per minute, water ¾ glass, vacuum 5 inches, cut off 15½ inches, lead ⅛ inch.

FRONT END—Water used per minute 256 lbs., water used per hour 15360 lbs., water used per indicated H. P. per hour 26.4 lbs., gross pressure 107.4 lbs., back pressure 7.1 lbs., mean pressure 100.3 lbs., H. P. 581.7, proportion of back to gross pressure 7 per cent.

BACK END—Water used per minute 257.9 lbs., water used per hour 15474 lbs., water used per indicated H. P. per hour 26.5 lbs., gross pressure 107.0 lbs., back pressure 6.3 lbs., mean pressure 100.7 lbs., H. P. 584, proportion of back to gross pressure 6 per cent.



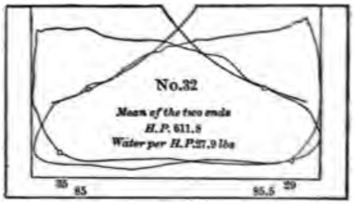
April 29, 1878.—4⅝ inch single nozzle, 6th notch, not throttled, boiler pressure 145 lbs., revolutions 156 per minute, water ¾ glass, cut off 15½ inches, lead ⅛ inch.

Front End—Water used per minute 342.39 lbs., water used per hour 20543 lbs., water used per indicated H. P. per hour 26.5 lbs., gross pressure 108.6 lbs., back pressure 12.5 lbs., mean pressure 96.1 lbs., H. P. 776, proportion of back to gross pressure 11 per cent.

Back End—Water used per minute 346.5 lbs., water used per hour 20790 lbs., water used per indicated H. P. per hour 26.25 lbs., gross pressure 109.6 lbs., back pressure 11.6 lbs., mean pressure 98.0 lbs., H. P. 792, proportion of back to gross pressure 10 per cent.

Train 45 loaded box cars, 800 gross tons, engine and tender 54 tons, total of train 854 tons, temperature of gases in smoke-box 1100 deg. Fah.

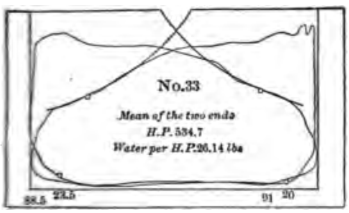
Short grade of 20 feet per mile.



November 1, 1878.—Compound nozzle, 4½ inches double and 4 inches single, 6th notch, not throttled, boiler pressure 134 lbs., revolutions 148 per minute, water ¼ glass, vacuum 5 inches, cut off 15½ inches, lead ⅛ inch.

Front End—Water used per minute 283 lbs., water used per hour 16980 lbs., water used per indicated H. P. per hour 28 lbs., gross pressure 94.6 lbs., back pressure 15.7 lbs., mean pressure 78.9 lbs., H. P. 605.3, proportion of back to gross pressure 16 per cent.

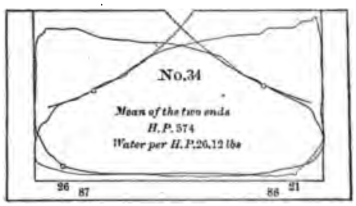
Back End—Water used per minute 286 lbs., water used per hour 17160 lbs., water used per indicated H. P. per hour 27.75 lbs., gross pressure 94.0 lbs., back pressure 13.4 lbs., mean pressure 80.6 lbs., H. P. 618.4, proportion of back to gross pressure 14 per cent.



November 29, 1878.—Compound nozzle, 4½ inches double and 4½ inches single, 6th notch, not throttled, boiler pressure 139 lbs., revolutions 112 per minute, water ½ glass, vacuum 4½ inches, cut off 15½ inches, lead ⅛ inch.

Front End—Water used per minute 235.2 lbs., water used per hour 14112 lbs., water used per indicated H. P. per hour 26.28 lbs., gross pressure 99 lbs., back pressure 6.4 lbs., mean pressure 92.6 lbs., H. P. 537, proportion of back to gross pressure 6 per cent.

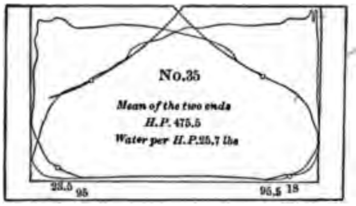
Back End—Water used per minute 230.6 lbs., water used per hour 13836 lbs., water used per indicated H. P. per hour 26 lbs., gross pressure 97.4 lbs., back pressure 5.6 lbs., mean pressure 91.8 lbs., H. P. 532.4, proportion of back to gross pressure 6 per cent.



December 2, 1878.—Compound nozzle, 3½ inches double and 4½ inches single, 6th notch, not throttled, boiler pressure 133 lbs., revolutions 124 per minute, water ½ glass, vacuum 4½ inches, cut off 15½ inches, lead ⅛ inch.

Front End—Water used per minute 249.9 lbs., water used per hour 14994 lbs., water used per indicated H. P. per hour 26.24 lbs., gross pressure 97.1 lbs., back pressure 8.2 lbs., mean pressure 88.9 lbs., H. P. 571.3, proportion of back to gross pressure 8 per cent.

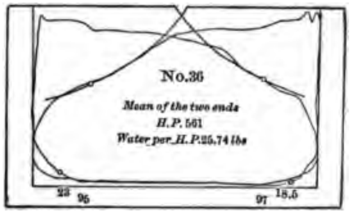
Back End—Water used per minute 250.6 lbs., water used per hour 15036 lbs., water used per indicated H. P. per hour 26 lbs., gross pressure 96.9 lbs., back pressure 7.1 lbs., mean pressure 89.8 lbs., H. P. 577, proportion of back to gross pressure 7 per cent.



DECEMBER 23, 1878.—Compound nozzle 4½ inches double and 4¾ inches single, 6th notch, not throttled, boiler pressure 135 lbs., revolutions 92 per minute, water ½ glass, vacuum 4 inches, cut off 15½ inches, lead ⅛ inch.

FRONT END—Water used per minute 202.8 lbs., water used per hour 12,168 lbs., water used per indicated H. P. per hour 25.7 lbs., gross pressure 104.1 lbs., back pressure 4.7 lbs., mean pressure 99.4 lbs., H. P. 474, proportion of back to gross pressure 4 per per cent.

BACK END—Water used per minute 204.4 lbs., water used per hour 12,261 lbs., water used per indicated H. P. per hour 25.7 lbs., gross pressure 103.7 lbs., back pressure 3.7 lbs., mean pressure 100.0 lbs, H. P. 477, proportion of back to gross pressure 4 per cent.



DECEMBER 25, 1878.—Compound nozzle 4½ inches double and 5 inches single, 6th notch, not throttled, boiler pressure 140 lbs., revolutions 108 per min., water ½ glass, vacuum 3¾ inches, cut off 15½ inches, lead ⅛ inch.

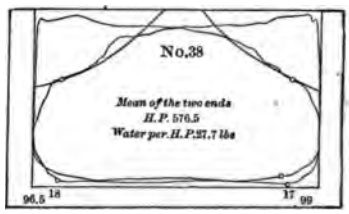
FRONT END—Water used per minute 241.9 lbs., water used per hour 14,514 lbs., water used per indicated H. P. per hour 25.76 lbs., gross pressure 106.0 lbs., back pressure 5.4 lbs., mean pressure 100.6 lbs., H. P. 563.4, proportion of back to gross pressure 5 per cent.

BACK END—Water used per minute 239.6 lbs., water used per hour 14,376 lbs., water used per indicated H. P. per hour 25.72 lbs., gross pressure 104.5 lbs., back pressure 4.7 lbs., mean pressure 99.8 lbs., H. P. 558.9, proportion of back to gross pressure 4 per cent.

APRIL 29, 1878.—4⅝ inch single nozzle, 7th notch, not throttled, boiler pressure 140 lbs., revolutions 84 per minute, water full glass, cut off 17¼ inches, lead 3-32 inch.

FRONT END—Water used per minute 233.12 lbs., water used per hour 13,987 lbs., water used per indicated H. P. per hour 27.8 lbs., gross pressure 123.6 lbs., back pressure 8.1 lbs., mean pressure 115.5 lbs., H. P. 503, proportion of back to gross pressure 6 per cent.

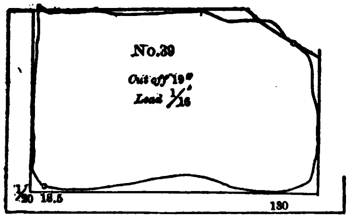
BACK END—Water used per minute 233.12 lbs., water used per hour 13,987 lbs., water used per indicated H. P. per hour 27.21 lbs., gross pressure 125.6 lbs., back pressure 7.5 lbs., mean pressure 118.1 lbs., H. P. 514, proportion of back to gross pressure 6 per cent.



DECEMBER 25, 1878.—Compound nozzle 4½ inches double and 5 inches single, 7th notch, not throttled, boiler pressure 138 lbs., revolutions 104 per min., water ½ glass, vacuum 4¼ inches, cut off 17¼ inches, lead ⅛ inch.

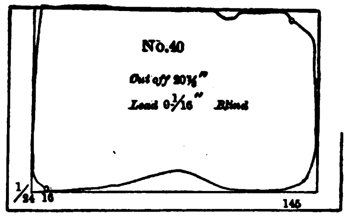
FRONT END—Water used per minute 268.8 lbs., water used per hour 16,128 lbs., water used per indicated H. P. per hour 28 lbs., gross pressure 113.3 lbs., back pressure 6.2 lbs., mean pressure 107.2 lbs., H. P. 577, proportion of back to gross pressure 6 per cent.

BACK END—Water used per minute 262.7 lbs., water used per hour 15,762 lbs., water used per indicated H. P. per hour 27.4 lbs., gross pressure 111.6 lbs., back pressure 4.8 lbs., mean pressure 106.8 lbs., H. P. 576, proportion of back to gross pressure 5 per cent.



APRIL 29, 1878.—4⅝ inch single nozzle, 8th notch, not throttled, boiler pressure 142 lbs., revolutions 56 per minute, water full glass.

FRONT END—Water used per minute 191.8 lbs., water used per hour 11,508 lbs., water used per indicated H. P. per hour 30.9 lbs., gross pressure 133.5 lbs., back pressure 5.2 lbs., mean pressure 128.3 lbs., H. P. 372.3, proportion of back to gross pressure 4 per cent.



APRIL 29, 1878.—4⅝ inch single nozzle, 9th notch or full gear, not throttled, boiler pressure 139 lbs, revolutions 52 per minute, water ¾ glass, vacuum 6½ inches.

FRONT END—Water used per minute 198.2 lbs., water used per hour 11,890 lbs., water used per indicated H. P. per hour 33.7 lbs., gross pressure 136.3 lbs., back pressure 5.2 lbs., mean pressure 131.1 lbs., H. P. 353.4, proportion of back to gross pressure 4 per cent.

RECAPITULATION.

The following remarks have reference *only* to the distribution in the first six notches from the center or mid-gear, and for a freight locomotive having cylinders 16½ by 24 inches.

1. The form of the nozzle, whether double or single, influences principally the exhaust line, or line of counter pressure, although its influence is felt in all the other lines, notably that of release and compression. It affects the lines of admission and expansion from compression raising the initial pressure.

2. A difference in diameter from 3½ to 4½ inches does not, with the double form of exhaust pipe, make much difference in the quality of the exhaust except at very high speeds and initial pressures. In the first four notches there is not much gain in using 3½ inch instead of 3¼ inch nozzles—this having been proved in former experiments.

3. In the fifth and sixth notches, especially the last, cutting off at 15½ inches of the stroke, the resistance or friction in passing through the steam port is greater than the resistance due to the nozzle, the area of the port 16.5 square inches and that of the nozzle 4½ or 15.9 square inches, being nearly equal.

4. In the single nozzle a difference in size is very marked. The difference in the consumption of steam, per indicated H. P., between the 4 inch and 4⅝ inch nozzles being about 4 per cent. in favor of the larger—being somewhat less in the first four notches, and rather

more than this in the fifth and sixth, greatly depending in all notches on speed and initial pressure.

5. The back pressure with the single nozzle is much greater than with the double form, being in the single form very much influenced by the size of the nozzle, speed, and initial pressure.

6. The communication between the two cylinders through the single form of blast pipe, which permits the waste steam from the one to pass to the other, causing a high back pressure, is not so prejudicial to economy as would at first be supposed, this steam being retained and compressed in the clearance space, and giving out useful work during the succeeding stroke.

It has, however, an indirect effect; the engine could in many cases, were this back pressure absent, develop more power in a given notch, and so use the steam more expansively, instead of dropping the lever into a lower notch and running the engine with a partly opened throttle.

7. We may consider the power to be obtained with 5 per cent. less steam in the double than in the single form in a freight engine, under the most favorable circumstances of diameter of nozzle, speed, and initial pressure.

In a fast-running passenger engine with a heavy train this increased expenditure of steam would be still further increased, and back pressure would become so great as to prevent the attainment of a very high speed.

8. The compound nozzle in its most favorable form, 4½ inch double and 5 inch single, is superior to the double form of nozzle where each of the nozzles are 3½ inches, and this latter has been proved superior to the single form.

The compound nozzle gives a superior line of release, which falls much nearer to the atmospheric line, and, in consequence, gives a much better exhaust.

Even at a speed of 21 miles an hour, and with a boiler pressure of 138 pounds, there is no evidence that the steam "blows over" with this nozzle—see Card No. 29.

In fact, we must consider this a most perfect exhaust, as far as influenced by the diameter of the nozzle—the attainment of perfection being accomplished only by increasing the size of the steam port, or making it much shorter.

9. Size of Port.—The steam port of this engine is, at the valve seat, $13\frac{3}{4}$ by $1\frac{3}{16}$ inches. This increases after leaving the face to $16\frac{1}{2}$ inches long and $1\frac{1}{2}$ inches wide or deep. From what has been said, it would be an improvement to increase the size of the port at the face to $16\frac{1}{2}$ by $1\frac{1}{2}$ inches. The only objection to this increase would be a trifle more friction between the rubbing surfaces of valve and valve-seat.

It has been seen in all the cards that the steam during admission is considerably wire-drawn and consequently the power developed with a given boiler pressure and speed is not as high as it should be, even supposing the work to be done with a similar consumption of steam per indicated H. P., which would not be the case.

That the gradual and insufficient opening of the port is the cause of this there is no doubt, as notice the effect on the admission line of the gradual closing of the port by the valve in Cards Nos. 39 and 40.

By an increase in the size of port to $16\frac{1}{2}$ by $1\frac{1}{2}$ inches at the face, we would obtain:

1st. An increase of power with a given boiler pressure and speed.

2d. A more perfect exhaust.

3d. A slight decrease in the amount of steam used per indicated H. P. per hour.

Against these advantages we have a little more friction of the valve, which is, I think, over-estimated in importance.

10. Clearance.—This engine has a large clearance space between the piston, at the end of its stroke, and the valve face, equal to 465 cubic inches, or .091 of the cylinder contents.

This large clearance is due to the size of the steam port, the distance between the piston, at the end of its stroke, and the cylinder head being only $\frac{1}{2}$ inch. Whether this clearance space is or is not too large these experiments do not satisfactorily prove.

That this large clearance is of great advantage with the single nozzle is very evident, especially where the back pressure, from imperfect release or from the "blow-over," is excessive, as in the case of the 4 inch nozzle.

As shown in former experiments, there is a gain in power with a large clearance space.

We have seen that it is desirable to keep the size of the steam port as large as possible to obtain a perfect exhaust, and this is es-

pecially the case in the lower notches, from the fifth to full gear, and therefore we must, necessarily, have large clearance, and in the first four notches compression is great and we require clearance to reduce it. Further, there is no reason to suppose that the work is done at a higher cost with this large clearance space; on the contrary, it is believed to be economical.

Short, large ports, at the extreme ends of the cylinder, and worked by two valves, by giving a perfect, or nearly perfect, exhaust, would leave but little vapor in the cylinder to be compressed, and in such case clearance could be reduced, as by such an arrangement it would certainly be.

11. SPEED.—The effect of speed on the economical development of power is dependent greatly on the form of nozzle.

It is more economical to develop power by high speed, when the exhaustion is of a high order, as in the compound nozzle, No. 29, than with the single nozzle of 4 inches in diameter, as in No. 24. With the exception of those cards, taken with the 4 inch nozzles, the most economical speed appears to be 150 revolutions, or 25 miles an hour.

12. BOILER PRESSURE.—As proved in my last paper, and in these indicator cards, the higher the initial pressure the greater, in proportion, is the amount of power developed, and the less the proportion of back to gross pressure, and the power is produced with less steam. When high pressure is used the initial pressure is proportionally higher, which contributes to economy.

13. LEAD.—Lead has an important effect on the distribution of the steam in all notches, notably the fourth, fifth, and sixth.

It raises the steam line up to that of boiler pressure and maintains this pressure for a short period during admission, giving the valve time, as it were, to open the port sufficiently to admit the necessary steam to keep the admission line well up to that of boiler pressure.

The effect of worn valve gear, or loss of lead, is well illustrated in all cards taken with the compound nozzle, being later in date by several months than those taken with the single or double nozzle, during which time the engine had run a good many miles.

Lead also affects the line of release, and there is no doubt that all of these cards would be improved with a larger amount.

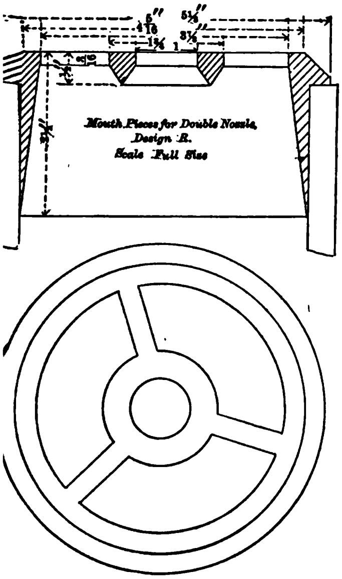
uare inches, or somewhat less than the $3\frac{1}{2}$ inch nozzles, were ied.

The engine steamed about the same as with the $3\frac{1}{2}$ inch nozzles ith a light train, and it was sometimes thought better. But with a ɜavy train they were a complete failure; the engine would not steam ell; in fact, it was difficult to get along at all. The smoke box as not cleared of cinders, which about half filled it while working.

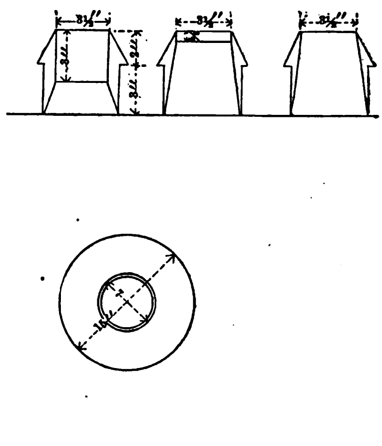
By changing the conical for the ordinary petticoat pipe the engine eamed much better, and the smoke box was entirely cleared of nders.

I may here mention that this form of nozzle was tried on a passnger engine, the area being the same as the nozzle in use. After good many experiments we had to abandon it as a failure.

The discharge of the steam is broken up, as desired, but the gine did not steam so well as with the plain nozzle.



Mouth Pieces for High Double Nozzle.



FORM OF MOUTH OF NOZZLE.—The mouth pieces of the double ɔzzle were bored out in three ways.

1. Bored parallel for a length of 3 inches from the mouth.
2. Bored parallel for a length of ⅝ inches from the mouth.
3. Bored up to a sharp edge at mouth.

A number of trials were made with each of these forms, but no difference was found to result from their use, all appearing to steam equally well.

If anything, the nozzle bored up to mouth was thought to be the mildest in its action on the fire.

"SMOKE STACK."—In experiments from No. 64 the engine was fitted with a new stack, shown in sketch.

It is smaller than the previous one, being 14 inches in diameter at the smallest part, and tapers up to 18½ inches at top. It is also one foot shorter. The engine steamed better with this stack than with the previous one.

This form of stack, increased to 15 inches in diameter at the smallest part, has been substituted for a stack 16 inches at smallest part and tapering to 19 inches at top, and one foot longer in freight engines with cylinders 18 by 24 inches with a decided improvement in steaming. A stack exactly similar to sketch has lately been put on one of these larger engines with an apparent improvement.

There is no difference in steaming between stacks 5 feet 9½ inches and 6 feet 9½ inches high.

This was thoroughly tried on a passenger engine with different sizes of nozzle and repeated changes in the height of the stack. The engine, however, made steam much more freely when standing in stations, and steam was "got up" quicker with the longer stack.

The coal in all these experiments may be taken to be the same, and the engine was run by the same driver and fireman in all experiments up to No. 78, and great care was taken always to run the engine the same way. In experiments from No. 78 the engine was run by other men, and although equally as great care was taken, it must be stated that they were not so well accustomed to the road and train as the other men, and the results are not so regular.

In comparing the 10 up trips with the 11 down trips in experiments Nos. 1 to 21, taken under similar conditions, we find a superior evaporation of about 9 per cent. on the up trips due to the smaller and more regular train.

On the up trip the evaporation is about the same per pound of coal with trains averaging from 15 to 18 cars.

On the down trip, when the average train is more than 20 cars the evaporation is very much less per pound of coal, due to the irregular average during the trip.

The consumption of coal per car mile is less on the down trips, on account of the larger average number of cars.

Comparing these experiments with Nos. 44 to 63, with the double nozzle 3½ inches in diameter, we have for the up trips a similar evaporation, while on the down trips it is 3 per cent. less in those with the single nozzle.

The difference in the size of the trains is very great, especially on the down trip.

If the trains with the double nozzle had been as large as with the single one, the amount of water evaporated per pound of coal would have been much less.

As a proof of this effect with large trains, we have only to compare experiments Nos. 44 to 63 with Nos. 64 to 77. Though the trains in the later experiments are not much larger, yet we have a lower evaporation of 5 per cent. in water per pound of coal.

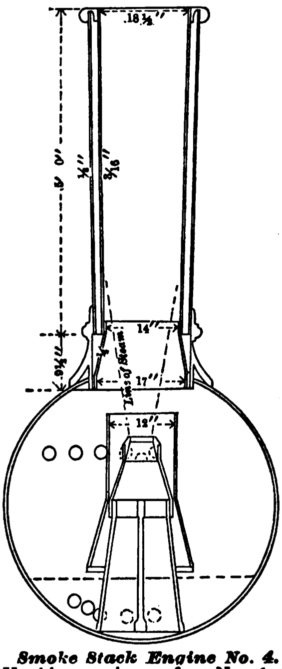
Comparing these experiments, taken under more favorable conditions—new smoke stack, wheels turned up, and valves faced—with those with the single nozzle, we find the latter to give better results by about 4 per cent., although with heavier trains.

The evaporation per pound of coal is much the same with the two forms of nozzle with light trains of about 15 cars. With heavy trains of 30 to 45 cars the evaporation with the single nozzle is much superior—I would say at least 15 per cent. This is not satisfactorily proved in these experiments, as the trains were not heavy, and the average number of cars hauled during the trip very irregular.

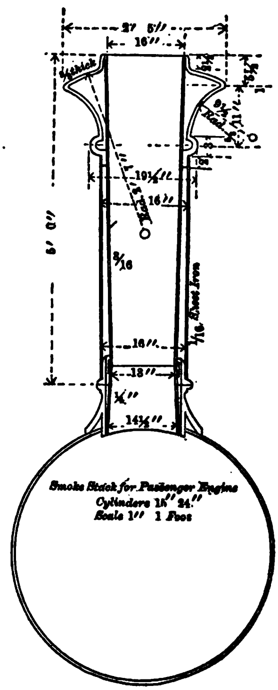
The single nozzle has a much milder effect on the fire, especially when pulling on grades and in heavy switching. The draught seems to be more constant, the air passing through the bars in a steady stream, and not with a succession of blasts as in the double form. The coal on the bars is less agitated with the single nozzle, and much less fire or red hot coke is thrown from the stack. The vacuum in the smoke

box is more constant, as shown by the oscillation of the water in the vacuum gauge.

In the double nozzle the steam is not discharged directly under or concentric with the smoke stack, but on one side of it. Since this steam, being discharged at an angle of about 9 degrees, would not strike within the base of the stack, a petticoat pipe is required to convey it to the center. This discharge is not so effectual as that of the single form, which is directly under and concentric with the chimney.



Smoke Stack Engine No. 4.
Used in experiments from Nos. 64 to 95.



In this we have the secret of the larger size of the single nozzle. A $4\frac{1}{2}$ inch single being equal to two nozzles of $3\frac{1}{2}$ inches, or rather to one, as the discharge from each cylinder is independent of and does not occur at the same time as that of the other.

The steam from the single nozzle fills the stack like a plunger,

effectually driving out all the smoke or gases. The gases from all parts of the smoke box rush with equal force to fill the higher vacuum formed in the stack, and the "steam plunger," working in quick succession, maintains constant this equal flow of the gases.

Not so with the double nozzle; the steam striking with more force on one side of the petticoat pipe is thrown to the opposite side of the stack, losing its force and not so effectually driving out the gases. Here the vacuum within the petticoat pipe is much higher than that outside, and concentrates the draught at the lower part of the smoke box, and the fire is worked much more through the lower row of tubes and more fire thrown from the stack.

The gases do not flow to the stack in a constant stream, there being a comparative lull in the flow between each discharge.

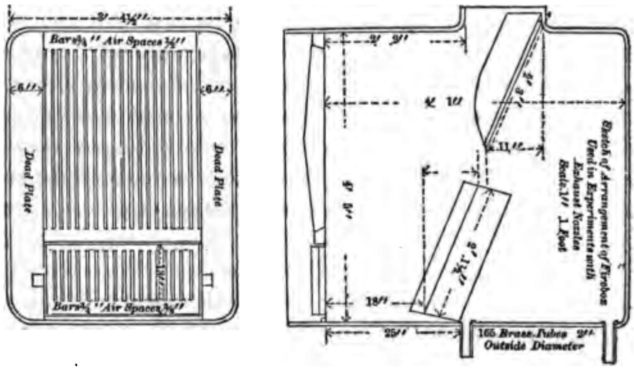
This jerking or inconstant action of the double nozzle is visible in the fire box, the fire being much agitated by the force of the blast, the coal on the bars rising and falling with each discharge.

To allow for this lull, caused by the inferior discharge of the steam, the double nozzle must be made much smaller than the single one. The vacuum is much higher during the discharge, which causes the violent oscillation of the water in the gauge—the mean vacuum being much higher than with the single form.

It will now be seen why the petticoat pipe is so necessary with the double nozzle.

In the single form the engine steams better without it, the vacuum being more constant and equal in all parts of the smoke box. The friction of the steam on a larger volume of gas, inducing a current and carrying it out with it, is no doubt the cause why the nozzle acts better without the pipe. A pipe of some kind is, however, necessary to clear the smoke box of cinders and keep the lower row of tubes clean.

The single nozzle works the fire most under the door, lifting the small particles of coke and throwing them against the tube sheet. The use of a petticoat pipe a couple of inches above the surface of the brick in the smoke box, and firing most under the door obviates this evil.



The double nozzle works the fire most under the box next the tube sheet, and we find the best position of petticoat pipe to be from 12 to 14 inches above the bottom of box—4 or 5 inches above the brick—and 5 inches below the base of stack. The use of the brick arch in both cases is of advantage.

BRICK ARCH.

In comparing experiments Nos. 37 to 43, without the brick arch, with experiments Nos. 44 to 63, with the arch, we find the economy in evaporation attending its use to be about 4 per cent. The general average shows it to be greater, but the trains hauled without it were not so favorable—the up trains being smaller while the down trains were much heavier.

I would consider the economy stated to be about right, from observation on other locomotives.

The brick arch, fitting close to the tube sheet, helps to prevent cinders from being drawn into the smoke box, prevents the appearance of smoke and enables the engine to steam better. It also lengthens the life of the beading on the ends of tubes in the fire box.

As shown by the indicator the double is superior to the single form of nozzle for the exhaustion of the steam from the cylinder, while these experiments prove that the amount of water evaporated per pound of coal is much greater with the single form.

That is: Each nozzle is, in something, superior to the other.

The question then arises, can not we combine these two forms and obtain a nozzle that will give us the superior exhaust of the double nozzle with the superior evaporative qualities of the single one?

This has been attempted—and, I think, accomplished—in what I have called the compound nozzle, shown in Sketch No. 4.

When first tried the double nozzles were each $4\frac{1}{2}$ inches and the single nozzle 4 inches in diameter. The engine steamed remarkably well; but, as shown in the indicator cards, the quality of the exhaust was of the most inferior kind.

The single nozzle was then enlarged to $4\frac{1}{2}$ inches. This greatly improved the exhaust, and the engine steamed as well if not better than with the 4 inch nozzle.

The ordinary petticoat pipe was used, reaching to within 1 inch of the brick on the back and to within 2 inches on the front side.

With this nozzle the engine steamed better than with the single nozzle $4\frac{5}{8}$ inches in diameter, and had a still milder effect on the fire. In fact, the steaming of the engine was perfect with light and with heavy trains. Little, if any, fire was thrown, even when taking a grade with a very heavy train.

Two $3\frac{1}{2}$ inch mouth-pieces were then put in the double and a $4\frac{1}{2}$ inch one in the single orifice. The engine steamed well, but not quite so well as before.

The single nozzle was then enlarged to 6 inches. This improved steaming, which was quite as good as with the three $4\frac{1}{2}$ inch nozzles.

This nozzle affected the fire in the same way as the $3\frac{1}{2}$ inch double nozzle, agitating the coal on the grate and throwing more fire than the $4\frac{1}{2}$ inch compound.

The double nozzles were then enlarged to $4\frac{1}{2}$ inches, and the single one to $4\frac{3}{4}$ inches. The engine steamed well, but the effect was that of the double nozzle, although no more fire was thrown than when all three were $4\frac{1}{2}$ inches in diameter.

The single nozzle was further increased to 5 inches. This was an improvement on the last, the engine steaming somewhat bet-

ter, but the action of the blast was undoubtedly that of the double nozzle.

Why should two $4\frac{1}{2}$ inch nozzles steam so much better in this case than two $3\frac{1}{2}$ inch nozzles in the double form? As stated, the action is decidedly that of the double form—a proof that the 5 inch nozzle does not affect the quality of the blast; simply that the 5 inch single nozzle acts as a species of convey pipe, conducting the steam from the double nozzle to the center of the chimney.

The single nozzle was further increased to $5\frac{1}{2}$ inches and 6 inches, but these sizes proved too large—the engine did not steam well.

The double nozzles were next increased to $4\frac{3}{4}$ inches, and the single to 5 inches; but this last, being found too large, was reduced to $4\frac{3}{4}$ inches. The engine steamed well, but not so well as desirable.

Three $4\frac{5}{8}$ inch nozzles would be about the right size, and as large as could be economically used on this engine.

We have fitted the compound nozzle—each of the three mouthpieces being $4\frac{1}{2}$ inches in diameter—on a number of freight engines having cylinders $16\frac{1}{2}$ by 24 inches and 18 by 24 inches. These engines had high double nozzles, varying in size from $3\frac{1}{4}$ to $3\frac{3}{8}$ inches in diameter and 27 inches above the bottom of smoke box.

In every case the engine steamed to perfection with the compound nozzle, and "worked" the fire more evenly than with any other nozzle tried.

Since fitting up the engines with these nozzles we have not been troubled with any complaints about fires on the line of road, and all engines are using an open stack similar to sketch. The petticoat pipe in these engines was arranged similarly to that of No. 4 and the smoke box and lower row of tubes perfectly cleared of cinders.

We found in No. 4, with the compound nozzle, that the smoke box was not cleared of cinders with the petticoat pipe within 2 inches of the brick on the front.

(In all engines the bottom of smoke box is laid with brick about 8 to 10 inches deep at door and tapering to the bottom of lower row of tubes.)

On account of the slope of this brick bottom the back end of the petticoat pipe is several inches above the brick.

If a sight hole be opened in the smoke box it will be seen that the cinders are drawn through the tubes with great force and are thrown against the smoke-box door, forming a pile which gradually slopes down to the tube sheet unless cleared out.

To the back end of the petticoat pipe we fitted a piece of sheet iron extending half-way round and about one inch above the brick—the front part, as stated, being 2 inches high. This arrangement, concentrating the draught in the front part of smoke box, effectually clears out the cinders without unnecessarily drawing the lower tubes, which are also kept clear.

No cinders, much less large, dangerous ones, are thrown out by the blast, exept through the petticoat pipe. If a piece of wire netting were placed in the petticoat pipe, to keep the large cinders in the smoke box, no fire would be thrown, under any conditions of train and speed. These large cinders would, by striking on the netting, become broken up and cooled before passing out.

EXPERIMENTS WITH COMPOUND NOZZLES.

Comparing experiments Nos. 78 to 95 with those of Nos. 64 to 77, taken under similar conditions, although with another driver and fireman, we find the compound nozzle to give superior results. The evaporation per pound of coal being over 6 per cent. greater with the compound, even with a heavier train, and the coal used per car mile about 15 per cent. less.

The weather during the experiments with the compound nozzle was somewhat warmer, and no doubt the cars ran easier; there was also less switching at stations, but no very correct account was kept of this service.

The experiments with the compound nozzle are by no means satisfactory, and can hardly be compared with the previous ones. I regret that another change in the men running the engine prevented a continuance of the experiments, which promised to be so interesting.

Our monthly "Consumption Sheet" shows a remarkable decrease in the consumption of coal per car mile, not with one, but with all

the engines fitted with the compound nozzle—a decrease in the case of heavy trains of at least 15 per cent.

RECAPITULATION.

EXPERIMENTS ON THE EVAPORATION OF WATER PER POUND OF COAL WITH DIFFERENT FORMS OF EXHAUST NOZZLE.

The following remarks refer *only* to the evaporation of water per pound of coal, and have no reference to the value of the nozzle in the exhaustion of the steam from the cylinder.

1. The single nozzle is much superior to the double nozzle, especially with heavy trains, the evaporation of water per pound of coal being much greater.

2. Less fire or burning coal is thrown from the stack with the single nozzle, the quality of the exhaust being better.

3. The compound nozzle combines the advantages of both of these nozzles and is in every way superior to either.

4. A petticoat or convey pipe is necessary with the double nozzles to conduct the steam into the center of the stack.

With the single form it is not necessary, but in some form is of advantage to keep the smoke box and lower tubes clear of cinders.

5. The brick arch increases the steaming capabilities of the engine, assists in keeping cinders in the fire-box, prevents smoke, lengthens the life of tubes, and adds about 4 per cent. to the economy of the locomotive.

6. A decrease in the size of the smoke stack is a marked improvement, where the open pipe is used, its size depending, it is thought, on the form of the nozzle, whether single or double—a smaller stack being used to advantage with the single form.

7. With the compound nozzle of the height and form shown, and with a netting in the bottom or middle of the petticoat pipe, no fire need be thrown under the most unfavorable circumstances of train and grade.

8. By properly designing the grate bars, tapering them from, say $\frac{7}{8}$ or 1 inch at top to $\frac{1}{8}$ inch at bottom, and giving the proper amount of opening between them, from $\frac{1}{4}$ to $\frac{3}{8}$ inch is considered sufficient

an coal—the air can enter with great facility, and larger en, than $4\frac{1}{2}$ inches can be used. The size of stack influ- re than any other detail, their diameter.

plates decrease the facility of the air entering the fire- duce the diameter of the exhaust nozzles.

h no experiments have been made with them, their use is ered of great advantage in a freight engine, especially if e the size of the nozzle.

h Chilian coal the fire door should be kept wide open, and te is of advantage. This coal is highly gaseous, leaves d never cakes or clinkers. When the door is closed the ms better, but uses more coal and throws more fire.

ardiff (Welsh) coal which was smokeless, the engine tter and worked more economically with the door nearly Firing with Welsh coal had to be much heavier and pro- more air was required through the bars.

e was thrown with the Welsh coal. With a heavy train erior results to the Chilian coal, as shown in the sheet of ts.

THE VACUUM IN THE SMOKE BOX.

xperiments with the indicator, a definite value has been e distribution of the steam in the cylinder with different ozzle.

hardly be said of the experiments made to ascertain the aporation per pound of coal, there being so many causes gainst an exact conclusion.

v proposed, with the assistance of the vacuum gauge, to nite value to the quality of the exhaust as affecting the evaporation of water.

ch diagram was taken the vacuum in the smoke box was s face. These vacuums, from the first to the sixth notch, th given.

s taken with each form of nozzle are grouped together. pressure and number of revolutions are given, as they, rn the vacuum. Of course, all vacuums were taken with e wide open.

Experimen

EXPE

pound Nozzle, 3½ i
Single ....

Averag

For compariso

December 2, 1878-
pound Nozzle, 3½
Single ....

Averag

For comparis

December 23, 1878
pound Nozzle, 4½
Single ....

Averag

For comparis

December 25, 187
pound Nozzle, 4½
Single ....

Avera

For compari

In computin
2½ pounds pressure
15 rev. per min. is
These figure

Experiments with Exhaust Nozzles, Engine No. 4, Showing Vacuum in Smoke Box.

Notch from Center......... 1. 2. 3. 4. 5. 6.

AUGUST 18, 1876. Sketch No. 1.—3¼ inch low double nozzles.

NOVEMBER 23, 1876. Sketch No. 1.—3½ inch low double nozzles.

OCTOBER 7, 1876. Sketch No. 2.—3⅜ inch high double nozzles.

FEBRUARY 6, 1877. Sketch No. 3.—4 inch single nozzle.

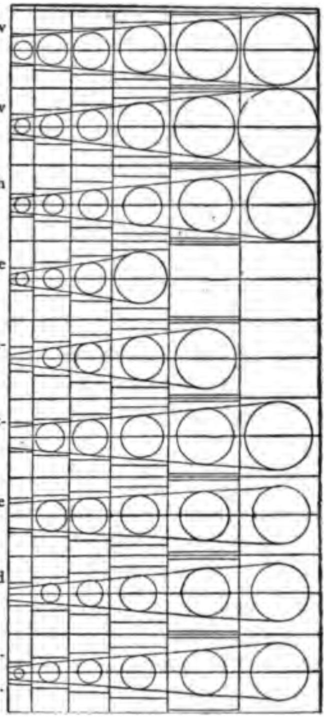
FEBRUARY 8, 1877. Sketch No. 3.—4⅜ inch single nozzle.

MAY 6, 1878. Sketch No. 3.—4½ inch single nozzle.

MARCH 5, 1878. Sketch No. 3.—4⅝ inch single nozzle.

NOVEMBER 1, 1878. Sketch No. 4.—Compound nozzle; 4½ inch double and 4 inch single.

NOVEMBER 25 and 29, 1878. Sketch No. 4.—Compound nozzle; 4½ inch double and 4½ inch single.

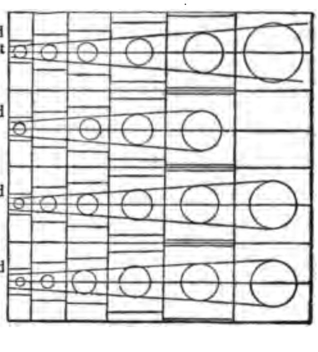


DECEMBER 2, 1878. Sketch No. 4.—Compound nozzle; 3½ inch double and 4½ inch single. Not steaming well.

DECEMBER 2, 1878. Sketch No. 4.—Compound nozzle; 3½ inch double and 6 inch single.

DECEMBER 23, 1878. Sketch No. 4.—Compound nozzle; 4½ inch double and 4¾ inch single.

DECEMBER 25, 1878. Sketch No. 4.—Compound nozzle; 4½ inch double and 5 inch single.



nozzle, and the compound form of three 4½ inch nozzles—the results are most regular.

The engine steamed well with all of these nozzles, with the exception of the compound 3½ inch double and 4½ inch single.

The vacuums with the 3½ inch low double nozzle are not very regular, and will not be compared with the others.

To still further facilitate comparison, I have introduced a condensed diagram, showing the vacuums produced by the most favorable sizes of the various forms used. It is drawn to the same scale of ¼ inch to the inch. The lines at right angles to the base line represent a line drawn through the center of the circles in the first and sixth notches. See page 155.

The height on these lines from which the inclined lines are drawn is equal to the diameter of the circle in those notches; otherwise, the height in inches of the vacuum.

By raising the exhaust pipe from 12 to 27 inches above the bottom of smoke box we have reduced the vacuum in the sixth notch about 15 per cent. The difference is not so marked in the first notch.

The single nozzle, 4⅝ inches in diameter, has further reduced the vacuum 13 per cent. below that of the 3⅜ inch high nozzle.

The amount of fire thrown with these forms, notably the 4⅝ inch single nozzle, is much less than with the 3½ inch low nozzles, the action of the blast being so much milder.

As here shown, it is owing to the lower vacuum in the smoke box. The height and form of the single nozzle having more influence on the air entering into the fire box, causing it to enter much more easily, and in a more constant stream.

It will be noticed that the vacuum in the higher grades of expansion is greater with the single nozzle than with the other forms. I can not give the reason for this.

The vacuum produced by the compound nozzle is still lower, that of the 4½ inch double and 5 inch single being 43 per cent. lower than the 3½ inch low double nozzle.

It will be noticed that the compound nozzle 4½ inch double and 4 inch single gives a very much lower vacuum than the 4 inch single, and it has also been shown to be slightly superior in the distribution of the steam in the cylinder.

It will be further noticed that the vacuum produced with the 3½ inch double and 4½ inch single, and with the single increased to 6 inches is about 25 per cent. less than that produced by the 3½ inch low nozzles, although the engine steamed much better with the compound form.

This is a very remarkable result of the combination of the two forms.

The vacuum produced by the compound nozzle 4½ inch double and 4¾ inch single is the same as with 4½ inch double and 5 inch single. A result that might be expected, as it acted the same as double nozzles in each case.

Not only does the lower vacuum in the smoke box keep the cinders in the fire box, but it lowers the temperature of the gases in the smoke box. On several occasions this temperature was 1,000 degrees to 1,100 degrees Fahrenheit, on a grade, with a train of 40 to 45 loaded cars, and with high double nozzles 3½ inches in diameter.

With the compound nozzle this fell to 800 degrees Fahrenheit, with a train of 42 cars on the same grade.

This is, of course, the reason why more water is evaporated per pound of coal with the nozzles that give the lowest and most constant vacuum.

It is in the fifth and sixth notches that the difference in the vacuum produced by different nozzles is greatest, and for this reason that the higher evaporation per pound of coal with the compound nozzle is most marked in those notches.

Although the vacuum with the 4½ inch double and 5 inch single compound nozzle is much lower than where the nozzles are each 4½ inches in diameter, the quality of the exhaust is superior in the latter, the action or effect being that of the single nozzle, while the first is that of the double form. Little if any more cinders are thrown with the smaller size, owing to this superior draught.

With the 4½ inch double and 5 inch single compound nozzle, the engine banked her fire next the tube sheet—that is, the coal or coke was lifted next the door and carried forward, falling against the tube sheet. This is undoubtedly caused by the single nozzle making a higher vacuum in the upper part of the smoke box, and affecting

the draught most through the upper rows of tubes, which act on the fire next the door.

This might be corrected by the use of a diaphram plate extending from the top to the middle of the tube sheet, or lower, or by some other such plan which, by increasing the draught through the lower tubes, would work the fire more evenly.

I have not sufficiently experimented with this compound nozzle. What has been done and said about its action shows that, to avoid throwing cinders, we must have a low and equal vacuum in all parts of the smoke box, which will then draw the supply of necessary air through all parts of the grate alike, causing a constant and mild draught.

RECAPITULATION.

1. The single nozzle gives a much lower vacuum in the smoke box than the double form, the engine steaming better with the single form.

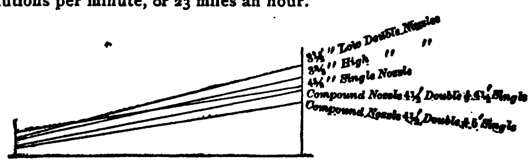
2. The compound gives a still lower vacuum than the single nozzle, and with still better steaming power.

3. The compound nozzle in any of the forms tried produces a very much lower vacuum in the smoke box than the $3\frac{1}{2}$ inch double nozzle.

4. Although a low vacuum in the smoke box is required to prevent cinders from being thrown, yet to obtain a maximum effect this vacuum must be a constant one, and not be the means of a succession of high and low vacuums.

Vacuum in Smoke Box.

Condensed diagram, showing relative vacuums produced by nozzles of equal steaming capacity, from first to sixth notch, with a boiler pressure of 135 pounds, and a speed of 140 revolutions per minute, or 23 miles an hour.



GENERAL RECAPITULATION.

As a general recapitulation, we may state that it has been proved that the English nozzle, when it can be made of a large size, is

superior to the American form, being more economical and throwing less fire.

That the "compound nozzle," or combination of the two forms, not only unites the good qualities of both in one, but gives a lower vacuum and higher evaporation than the English, and a more perfect exhaust than the American form.

That it is possible to prevent locomotives from throwing fire without using nettings and other obstructions to the draught—all that is required being proper attention to the details governing the free access of air to the fire, and those governing the size of the exhaust nozzle, working with a high boiler pressure and using the steam very expansively.

JOHN E. MARTIN.

On motion, the report was received.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I have failed to make such a report to this Convention upon the performance of locomotives as I would like; but I believe railroad companies are looking to this Association for something of this character. I think all members should send in statistics, so that we may have some data for comparison. We want to know whether the Mogul or the Consolidated engine will perform more work than the ordinary eight-wheel engine, and we want the statistics from parties using these engines, giving us the margin per ton per car hauled in their favor. The time is coming when railroad managers will look to this Association for reliable information in this matter, and I hope the members will give it more attention.

Mr. HAYES, Illinois Central Railroad—Mr. President, I would move that this Committee be appointed for another year, and, if necessary, add more members to it.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I think the Committee should be continued another year.

Mr. JOHANN, Wabash Railroad—Mr. President, I do not think any thing will be gained by adding more members to the Committee. The thing to do to help the Committee is for the members to answer the circulars. I think if the members would report the performance of their engines, etc., to the Committee in the proper form we would get all the information necessary.

Mr. HAYES, Illinois Central Railroad—Did Mr. Johann reply to the circular?

Mr. JOHANN, Wabash Railroad—Yes, sir; I replied to Mr. Woodcock, saying that I had no further information to give than what I had already given other committees published in previous reports. That is more than some members did.

Mr. HAYES, Illinois Central Railroad—It is not more than I did. I sent

the Committee the performance of our engines from the time I was connected with the road, and gave all the information I could.

Mr. JOHANN, Wabash Railroad—That is just exactly what I did, only I sent my statement to another committee some time ago. I think it would be well to continue the Committee, and probably they may have better success the coming year.

THE PRESIDENT—I would like to say to the members that it requires a great deal of labor for a committee to get up a circular and send to each member for information, and it is very discouraging to receive no reply to it. I hope the members will bear this in mind, and reply to the Committee circulars in future.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I would remark that it does not require a great deal of work to reply to our circulars. All the members have to do is simply to state what work their Mogul or Consolidated engine has done. We want to make a comparison from the replies received, and we can not make that comparison unless we get this information from each member.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, the Baltimore & Ohio, Erie, New York Central, and Pennsylvania are using these heavy engines to a greater extent than any other roads, but it seems impossible for us to get information as to their experience, as they are not actively represented in this Association.

Mr. JOHANN, Wabash Railroad—Mr. President, it will be very hard for us to get exact information in regard to this matter unless we lay down some general rule. I have received performance sheets showing 50, 60, and some as high as 70 miles to the ton of coal. It is impossible for me to do that and do any work. I do not think my engines can do any more than any other engines that are in the same service; they run about 40 miles to the ton of coal. On some reports the engines only show 22 miles to the ton of coal, and I think that that engine has done more work with better economy for the company than some engines that show 80 miles to the ton of coal.

Mr. BLACK, Dayton and Michigan Railroad—Mr. President, if the motion of Mr. Hayes to continue the Committee has not been seconded, I now second it.

THE PRESIDENT—I would like Mr. Hayes to say what his motion is.

Mr. HAYES, Illinois Central Railroad—My motion was that the Committee be continued for another year.

Motion carried.

Mr. WOODCOCK, Central Railroad of New Jersey—Mr. President, I would like to call the attention of the members to the tests conducted by Mr. John E. Martin, in South America, upon which he has spent a great deal of time and labor, and which is worthy the attention of the members. You will notice by referring to our previous reports that he has taken a great deal of interest in the Association, and has kindly furnished us with

full reports of the experiments he has made, and the Committee would like them printed in our report.

THE PRESIDENT—Motion is made and seconded that the papers and reports of Mr. Martin be received and printed in our Annual Report.

Motion carried.

THE PRESIDENT—Is there any thing further on the Secretary's table?

THE SECRETARY—Nothing.

THE PRESIDENT—The next business in order is the election of officers. The Constitution, Art. II, provides that the officers of the Association shall be a President, First and Second Vice-Presidents, Secretary and Treasurer. The above named officers to be elected separately by ballot at a regular meeting, and a majority of all votes cast shall be necessary to a choice.

Mr. WIGGINS, Houston, East & West Texas Railroad—I move that we postpone the election of officers for one year.

Mr. BLACK, Dayton & Michigan Railroad—I second the motion.

Mr. JOHANN, Wabash Railroad—I beg to dissent from that motion. It will be much more creditable to the President and other officers of the Association if we go into an election, and I move to amend that we now go into an election for officers.

Mr. SETCHEL, Little Miami Railroad—I second that motion.

THE PRESIDENT—Mr. Wiggins, will you accept the amendment?

Mr. WIGGINS, Houston, East & West Texas Railroad—I would like to have my motion put.

THE PRESIDENT—The first thing then will be on the amendment.

Mr. JOHANN, Wabash Railroad—Mr. President, I would like to say to Mr. Wiggins that I hope he will withdraw his motion, and allow us to go into an election for officers for the ensuing year.

Mr. WIGGINS, Houston, East & West Texas Railroad—I think my motion will save time.

THE PRESIDENT—The question is on the original motion that we postpone the election of officers for one year. I would like to say a few words before that motion is put and before an election is proceeded with. I should like the Association to choose some other man for President who, perhaps, can fill the office more creditably than I can. I have been an officer of the Association ever since it started, and I would much rather you would choose some one in my place. I do not believe in holding an office a life-time, as I said in my address.

Mr. HAYES, Illinois Central Railroad—Mr. President, that is my case. I have held the office of Treasurer ever since the organization of the Association, which is now eleven years, and I would rather you would choose some younger man than me for the position.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I would also be very much gratified if the Convention will select some

other man in my place. I think rotation in office is a very good thing, and one year is long enough for any man to hold office.

THE SECRETARY—Mr. President, it has been suggested that nominations be made for the different officers. I hope this will not be done. I do not want to place any members in the position of being obliged to vote contrary to what they think will be for the best interest of the Association. The Constitution does not require that any nominations be made, but it says that officers of the Association shall consist of a President, First and Second Vice-Presidents, Secretary and Treasurer, and I think they should be balloted for in such a manner as to allow every member to be entirely free to vote for the man he thinks best capable of filling the office without being tramelled by a nomination. Suppose there is a half dozen candidates on the first ballot for the same office. It will indicate at once the desire of the Association, and the next time the vote will be concentrated upon the man who has the highest number of votes, and it will give freedom in this matter which we have not had for a long time. I had been thinking of introducing a resolution excluding from our Constitution that rule which allows postponement of elections, for the reason that in talking with some of the members they seemed to think that it was a bad feature of our Constitution. A postponement unanimously voted for would seem to carry the idea that the officers were the ones desired. Still, under certain circumstances, perhaps some man would be elected that the members did not want, and yet they would feel diffident about making any opposition. Having been your Secretary for the past eight years, I will say to you now that I will only be too glad to surrender my office. But I wish to say to the Convention, if it is your desire I will serve the Association to the best of my ability; but if you *want* me to be your Secretary you must elect me by ballot.

Mr. SPRAGUE, Porter, Bell & Co.—Mr. President, I wish to say that I do not think there is any feeling of dissatisfaction among the members with our present officers, but I agree with our Secretary that members feel a delicacy in getting up in open Convention and expressing a preference for or against any one member. I think, as we have not had an election for some time, we should not postpone this election now. If we choose we can elect the same members, but let it be done by ballot, so we can have entire freedom in our choice of officers.

Mr. HAYES, Illinois Central Railroad—Mr. President, I also agree with Mr. Setchel and my friend Mr. Sprague. I think every one should be free to vote for whom he may think best adapted to the interests of the Association, and this can better be done by ballot. Members feel a delicacy in getting up in Convention and opposing postponement of an election, and it does not leave every man free to vote just as he pleases.

Mr. Wiggins then withdrew his motion.

THE PRESIDENT—It has been our custom to make nominations for the

various offices, but the Constitution does not require it. I will appoint for tellers in this election Mr. Wells and Mr. Young. Gentlemen will please prepare their ballots to vote for President of the Association.

THE SECRETARY—Mr. President, there have been 53 votes cast: Mr. Chapman received 32, Mr. Wells 10, Mr. Johann 5, Mr. Hayes 3, and Mr. Sedgley 3.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, Mr. Chapman is therefore elected.

Mr. HAYES, Illinois Central Railroad—Mr. President, if it is in order, I would move to make the vote unanimous.

Motion carried.

Mr. CHAPMAN—Gentlemen, I appreciate the honor conferred upon me, although I would much rather you had elected some one else to fill the position; but, as I said in my address, I have held the office of First Vice-President or President ever since the organization of our Association, and I consider it due the Association that some other member should have an opportunity to fill the position; but as you have elected me, I will try to serve you to the best of my ability, trusting that at the next meeting of the Association you will see fit to elect some other man for President. Thanking you, gentlemen, for the courtesy extended, I am yours for another year.

Mr. HAYES, Illinois Central Railroad—Mr. President, I move that we now go into an election for First Vice-President.

Motion carried, with the following result:

THE SECRETARY—Mr. President, 53 votes have been cast, of which Mr. Wells has received 40, Mr. Hayes 6, Mr. Sedgley 4, Mr. Johann 2, and Mr. Lauder 1.

THE PRESIDENT—I have the pleasure of announcing that Mr. Wells has been elected First Vice-President of the Association for the ensuing year.

Mr. WELLS—Gentlemen, I thank you for the compliment you have paid me, but I would much rather you had elected some one else—one who could fill the position of First Vice-President with much more credit and to better advantage than I. But, as you have seen proper to elect me, I will do all I can to advance the interests and usefulness of this Association. Again thanking you for the compliment, I yield to the regular business.

THE PRESIDENT—The next business in order is the election of Second Vice-President. I will state to the Association, before this ballot is taken, the reason why Mr. Lauder, who was elected Second Vice-President at St. Louis, is not present. I received a letter from him about two weeks ago stating that he would arrive in Cincinnati on last Saturday, but I received another letter later saying that it would be impossible for him to be here at all, on account of the dangerous illness of his daughter, who is not expected

to live from one hour to another. I make this statement that it may be understood why he is not with us.

The vote was then taken.

THE SECRETARY—There have been 52 votes cast, of which Mr. Lauder received 31, Mr. Sedgley 7, Mr. Flynn 5, Mr. Hayes 5, Mr. Setchel 3, and Mr. Johann 1.

THE PRESIDENT—Gentlemen, I have the pleasure of announcing to you that Mr. Lauder has been elected Second Vice-President of this Association for the ensuing year. I am very sorry he is not here to acknowledge his election for himself. Gentlemen will please prepare their ballots for the office of Secretary.

Vote taken, with the following result:

THE SECRETARY—There have been 54 votes cast, of which Mr. Setchel received 51, Mr. Miles 1, Mr. Hayes 1, and Mr. Johann 1.

THE PRESIDENT—I have the pleasure to announce that Mr. Setchel has been elected Secretary of this Association for another year.

MR. SETCHEL—Mr. President and Gentlemen, I have been Secretary of this Association for the past eight years, and in the administration of the business affairs of this office I have always endeavored to give no reasonable grounds for complaint, and this large vote which I have just received on my re-election has satisfied me that I have been measureably successful, and in my future duties, as in the past, I shall endeavor to do all I can for the interests and advancement of the Master Mechanics' Association. Gentlemen, please accept my thanks for this kind appreciation of my services.

THE PRESIDENT—The next business in order will be the election of a Treasurer.

Vote taken, with the following result:

THE SECRETARY—Mr. President, there have been 51 votes cast, of which Mr. Hayes received 48, Mr. Flynn 2, and Mr. Sedgley 1.

THE PRESIDENT—Gentlemen, I have the pleasure of announcing that Mr. Hayes has been elected Treasurer of this Association for the coming year.

Mr. HAYES—Mr. President and Gentlemen, I had hoped that some younger man would be elected as your Treasurer, but as you have deemed it proper to confer the honor upon me, I will endeavor to serve you as well as I have done in the past ten years.

THE PRESIDENT—Gentlemen, the hour for adjournment has arrived, but as there is probably an hour and a half required for further business of the Association, I would suggest that we adjourn for dinner, and then meet and finish our business. Will some one make a motion to that effect?

Mr. HAYES, Illinois Central Railroad—I move we now adjourn to meet again at half-past 3 o'clock.

THE PRESIDENT—Before putting the motion I wish to urge the importance of the members all being here promptly at the hour named.

Motion was then carried.

THIRD DAY, AFTERNOON SESSION.

President CHAPMAN in the Chair.

THE PRESIDENT—The next business in order will be the report on the place of holding our next Annual Meeting. The report of the Committee is in the hands of the Secretary, who will please read it.

Report on Place of Meeting.

To the American Railway Master Mechanics' Association:

GENTLEMEN:—Your Committee upon the next place of meeting would suggest the following cities as probably being the most convenient for a majority of the members:

New York City and Cleveland, Ohio.

Very respectfully,

J. DAVIS BARNETT,
JNO. F. DEVINE,
JNO. SWIFT,
Committee.

THE PRESIDENT—You have heard the report of your Committee, gentlemen, what is your pleasure in regard to it?

Mr. MILES, of Philadelphia—Mr. President, I move that Niagara Falls be added to the list.

Mr. JOHANN, Wabash Railroad—Mr. President, I wish to say that I rather feel disposed to make a permanent settlement of this question of meeting. I mention it for the reason that I do not suppose all members think as I do about having a permanent place of meeting, and I would like all of you to consider the matter. I do not think it helps the Association any to run around from one place to another, and for my part no place would suit me better for a permanent place of meeting than Cincinnati, as it is centrally located and easy to reach from all points, and I have spoken of it in private conversation with members for several years. If we should decide to have a permanent place of meeting we could secure a hall or rooms where we could keep our records and other property. I merely make this suggestion for the consdieration of the members, but I hope we will take some positive action upon the question before many years.

Mr. Miles' motion was carried.

THE PRESIDENT—The Secretary will please add Niagara Falls to the report. It has been suggested that we ballot, as it requires a majority of all votes to select the place. You will, therefore, prepare you ballots.

Vote taken, with the following result:

THE SECRETARY—Mr. President, 38 votes have been cast, as follows: Cleveland 19, Niagara Falls 9, Washington 1, Cincinnati 1, New York 19.

THE PRESIDENT—There being no choice, it will be necessary for another ballot. You will please prepare your ballots for another vote.

THE SECRETARY—Mr. President, 49 votes have been cast: New York 23, Cleveland 21, and Niagara Falls 5.

THE PRESIDENT—Gentlemen, you will please prepare your ballots again.

THE SECRETARY—Mr. President, 51 votes have been cast, of which Cleveland received 28, New York 21, and Niagara Falls 2.

THE PRESIDENT—I have to announce to you, gentlemen, that Cleveland has been selected as the place for our next Annual Meeting.

Mr. JOHANN, Wabash Railroad—Mr. President, now that Cleveland has been selected, I wish to say a word in regard to what I spoke of a few moments ago about our having a permanent place of meeting. I hope all the members will take it into careful consideration during the coming year, and discuss the question of selecting a permanent place of meeting at our next Convention in Cleveland. I think you will find either Cleveland or Cincinnati the best location, but as Cleveland is the place where the first meeting of our organization was held, it may be the proper place to hold all others. I hope the members will come prepared next year to decide this question.

Mr. LILLY, of Indianapolis—Mr. President, I have taken some interest in the remarks of Mr. Johann. Some one said that this Association could not raise or afford to keep a hall. Now, it seems to me that if members of influence should go to work they could get up a fund in Cincinnati, Cleveland, Louisville, Chicago, or other places competing for the permanent location of this Association, sufficient for our purpose. We have some instruments, and I think it will not be long before we have more such, and we will require a place to keep them. We have a dynamometer, but we need a microscope and other instruments for the purpose of testing oils and other matters that enter into the operation of railroads. To make experiments successful and reliable you must have the proper tools to do it with, and then we want a place to keep them. Now, if you will appoint Mr. Setchel on a committee to solicit contributions here in Cincinnati, and another member to see what he could raise in some other place, I have no doubt that you would find sufficient funds could be raised to make it an inducement to locate here, and erect a building that we would not be ashamed of.

THE PRESIDENT—The next business in order is the report of the Committee on Subjects for Consideration for the next year. The report is in the hands of the Secretary, who will please read it.

Subjects for Discussion at Next Annual Convention of 1880.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your Committee appointed to select Subjects for Discussion at the next Annual Meeting, beg leave to suggest the following:

1. Continuation of Boiler Improvements.

2. Comparative Performance of Locomotives, with regard chiefly to the Economy in their Performance.

3. The best means of Preventing Smoke from Locomotives, with due Economy in Fuel.

4. The best means of Preventing Noise from Safety Valves, and maintain the Safety of Boilers.

5. Shop Tools and Machinery for facilitating Repairs of Locomotives.

JOHN ORTTON,
JACOB JOHANN,
WM. FULLER,
J. F. DEVINE,
GEO. RICHARDS,
} *Committee.*

THE PRESIDENT—You have heard the report of your Committee, what action will you take upon it?

On motion, the report was received.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Mr. President, It has been our custom to vote an appropriation to our worthy Secretary, and I now move that his compensation for the past year be $600.

Mr. HAYES, Illinois Central Railroad—I second the motion.

Motion carried.

Mr. MILES, of Philadelphia—Mr. President, I rise to make a motion in which I know all the members will concur, and it is a happy privilege to now offer a resolution of thanks of this Association to our officers, beginning with the President and coming down to the Committees appointed to report on the various subjects.

THE PRESIDENT—Mr. Miles will please put his motion.

Motion carried.

THE PRESIDENT—The next business in order is unfinished business. Does any one know of any unfinished business to come up before this Association? Is there any thing in the hands of the Secretary?

THE SECRETARY—The Committee on Resolutions are ready to report.

THE PRESIDENT—The Secretary will read the report.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee appointed to draft resolutions respectfully beg leave to offer the following:

WHEREAS, The Rev. D. F. Harris, of the Columbia Congregational Church, kindly met with us and offered prayer for Divine blessing upon the deliberations of this our Twelfth Annual Meeting;

WHEREAS Colonel L. M. Dayton, on the part of the city, ex-

tended a generous welcome, numerous hospitalities, and the presentation of a magnificent locomotive of flowers, whose beauty is only excelled by the art displayed in its construction;

WHEREAS, Mr. Lewis Williams, General Manager of the Cincinnati, Hamilton & Dayton and the Cleveland, Columbus, Cincinnati & Indianapolis Railroads, has kindly tendered us a special train to visit Dayton and the Soldiers' Home;

WHEREAS, The Cincinnati Chamber of Commerce has honored the Association with an invitation to accept the privilege of the floor of that body;

WHEREAS, The Cincinnati Southern Railway, through its President, has extended an invitation to visit the great Kentucky River Bridge and other points;

WHEREAS, Colonel Gilmore & Sons, proprietors of the Grand Hotel, have been unremitting in their attentions to us as guests of their house, and have endeavored in every way to contribute to our comfort, and render our visit to this city one long to be remembered; and,

WHEREAS, The press of this city have given our Association due attention, and fairly reported our proceedings,

Be it therefore resolved, That the thanks of this Association are due, and are hereby tendered to, each and all the above named parties.

Very respectfully,

JAMES SEDGLEY,
H. N. SPRAGUE,
W. O. HEWITT,
} *Committee.*

THE PRESIDENT—There was a Committee appointed to draw up suitable memorials giving expression of the feelings of this Association upon the death of Mr. J. B. MORSE. This Committee can either do it here or forward it to the Secretary at their leisure.

Mr. BLACK, Dayton & Michigan Railroad—Mr. President, I move a copy of that resolution be forwarded to the family of the deceased.

THE PRESIDENT—That was included in the original motion. Is there any further business? If not, adjournment will be in order.

Mr. JOHANN, Wabash Railroad—Mr. President, I move we now adjourn to meet in Cleveland on the second Tuesday in May, 1880.

THE PRESIDENT—Gentlemen, a motion is made and seconded that we now adjourn to meet in Cleveland on the second Tuesday in May, 1880. I want to say, before I put the motion, that I thank you all for the kind attention

you have given to the business of this meeting, and I feel grateful to you for the leniency that you have shown and all kindness extended, and I hope that we may all meet in Cleveland next year and enjoy as pleasant and harmonious a time as we have had here at Cincinnati.

The motion to adjourn was carried.

J. H. SETCHEL, Secretary.

Committees and Subjects for Discussion at the Next Annual Meeting.

1.

Construction of Locomotive Boilers—Continued.

R. WELLS, Jeffersonville, Madison & Indianapolis;
S. J. HAYES, Illinois Central;
C. R. PEDDLE, Terre Haute & Indianapolis;
JACOB JOHANN, Wabash;
JAMES ECKFORD, Cincinnati, Hamilton & Dayton.

2.

Comparative Performance of Locomotives with Regard Chiefly to Economy in their Operations.

W. WOODCOCK, Central of New Jersey;
S. A. HODGMAN, Philadelphia, Wilmington & Baltimore;
JOHN E. MARTIN, Chillan, Concepcion & Talcahuanao.

3.

The Best Means of Preventing Smoke from Locomotives with Due Economy in Fuel.

E. T. JEFFERY, Illinois Central;
H. A. TOWNE, Northern Pacific;
SANFORD KEELER, Flint & Pere Marquette.

4.

Best Means of Preventing Noise from Safety Valves and Maintain Safety of Boilers.

GEORGE RICHARDS, Boston & Providence;
HOWARD FRY, Philadelphia & Erie;
W. F. TURREFF, Cleveland, Tus. Valley & Wheeling.

5.

Tools and Machinery.

J. DAVIS BARNETT, Grand Trunk;
H. G. BROOKS, Brooks Locomotive Works.
D. A. WIGHTMAN, Pittsburgh Locomotive Works.

6.

Trustees of Boston Fund, Printing and General Supervisory Committee.

N. E. CHAPMAN, Cleveland & Pittsburgh;
R. WELLS, Jeffersonville, Madison & Indianapolis;
J. N. LAUDER, Northern New Hampshire;
S. J. HAYES, Illinois Central;
J. H. SETCHEL, Little Miami.

7.

Arrangements for Next Annual Meeting.

N. E. CHAPMAN, Cleveland & Pittsburgh;
JAMES SEDGLEY, Lake Shore & Michigan Southern;
W. F. TURREFF, Cleveland, Tus. Valley & Wheeling.

CONSTITUTION.

AS AMENDED AT THE SIXTH ANNUAL MEETING, BALTIMORE, MAY 18, 1878.

PREAMBLE.

We, the undersigned Railway Master Mechanics, believe that the interests of the Companies by whom we are employed may be advanced by the organization of an association which shall enable us to exchange information upon the many important questions connected with our business. To this end do we establish the following

CONSTITUTION.

ARTICLE I.

SECTION 1. The name and style of this Association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

SEC. 1. The officers of the Association shall be a President, a First and Second Vice-President, a Secretary, and a Treasurer.

SEC. 2. The above-named officers shall be elected separately, by ballot, at a regular meeting, and a majority of all votes cast shall be necessary to a choice.

SEC. 3. The officers shall be elected for a term of one year, but in the event of the election being postponed shall continue in office until their successors shall be elected.

SEC. 4. Two tellers shall be appointed by the President to conduct the election and report the result.

ARTICLE III.

SEC. 1. It shall be the duty of the President to preside in the usual manner at all the meetings of the Association, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore.*

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members of the Association, and the name of the road they each represent; to receive and keep an account of all money paid to the Association, and at the close of each meeting deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills against the Association, and pay the same, after having the approval of the President; to deliver all paid bills to the Secretary at the close of each meeting, taking a receipted statement of the same; to keep an accurate book account of all transactions pertaining to his office.

ARTICLE IV.

SEC. 1. The following persons may become members of the Association by signing the Constitution, or authorizing the President or Secretary of the Association to sign for them, and pay the initiation fee of one dollar: Any person having charge of the Mechanical Department of a Railway known as "Superintendents," or "Master Mechanics," or "General Foremen," the names of the latter being presented by their superior officers for membership, also two Mechanical Engineers or the representative of each Locomotive Establishment in America.

SEC. 2. Civil and Mechanical Engineers, and others whose qualifications and experience might be valuable to the Association, may become Associate Members by being recommended by three active members. Their names shall then be referred to a committee, which shall report to the Association on their fitness for such membership. Applicants to be elected by ballot at any regular meeting of the Association, and five dissenting votes shall reject. The number of Associate Members shall not exceed twenty. Associate Members shall be entitled to all the privileges of active members excepting that of voting.

SEC. 3. Any person who has been or may be duly qualified, and signs, or causes to be signed, the Constitution, as member of the Association, remains as such until his resignation may be voluntarily tendered.

SEC. 4. All members of the Association will be liable for such dues as may be necessary to assess to defray the expenses of the Association, and any member who shall be two years in arrears for annual dues shall have his name stricken from the roll, and be duly notified of the same by the Secretary.

ARTICLE V.

SEC. 1. The regular meeting of the Association shall be held annually on the second Tuesday in May.

Sec. 2. Regular meetings shall be held at such place as may be determined upon by a majority of the members present at the previous meeting.

Sec. 3. An adjourned meeting may be held at any time and place that a majority of the members present at any meeting may elect.

Sec. 4. The regular hours of sessions shall be from 9 o'clock A. M. to 2 o'clock P. M.

Sec. 5. During the business sessions no communications shall be received or acted upon other than those pertaining to the business of the Association.

ARTICLE VI.

Sec. 1. This Constitution may be amended at any regular meeting of the Association by two-thirds vote of the members present.

RESOLUTION PASSED AT THE SIXTH ANNUAL MEETING, BALTIMORE, MARYLAND, MAY, 1873.

Resolved, That no expense shall be incurred by committees except by the unanimous consent of the General Supervisory Committee, given in writing to the chairman of said committee, stating the amount to be expended.

RESOLUTION ON BOSTON FUND, PASSED AT THE EIGHTH ANNUAL MEETING, NEW YORK, MAY, 1875.

Resolved, That the Boston Fund, amounting now, with accrued interest, to $3,620, be invested in Government securities to be selected by the duly appointed Trustees, and not to be disturbed for the purpose of expenditure unless authorized by the majority of members present in open convention, and then only after due notice of a motion to expend the same has been given at the session immediately preceding; and that the interest accumulating shall every year be invested in the same manner as the principal, and a full account of the same be duly reported with other financial statements.

RESOLUTION ADOPTED AT THE NINTH ANNUAL MEETING.

Resolved, That members of the Association who have been in good standing for a period of not less than five years, and who through age or other cause cease to be actively engaged in the mechanical departments of railroad service, may, upon the unanimous vote of the Association, be elected "Honorary Members," who shall have their dues remitted and be entitled to all the privileges of regular members except that of voting.

NAMES AND ADDRESS OF MEMBERS.

NAME.	ROAD.	ADDRESS.
Anderson, H.		147 Randolph street, Chicago, Ill.
Anderson, J. H.	N. Y. B. & P. Rd	Providence, R. I.
Anderson, R. H.	G. & C. Rd	Helena, S. C.
Anderson, Thos	C. C. & A. Rd	Columbia, S. C.
Alden, H. A	C. C. & B. & O. Rd	Brockville, Ont.
Britton, H. M.	N. Y. & N. E. Rd	Boston, Mass.
Britton, A. W.		Boston, Mass.
Boon, J. M	P. Ft. W. & C. Rd	Fort Wayne, Ind.
Bushnell, R. W	B. C. R. & N. Rd	Cedar Rapids, Iowa.
Brastow, L. C.	L. & S. Rd	Ashley, Pa.
Boyden, G. E	N. Y. & N. E. Rd	Boston, Mass.
Brooks, H. G	Brooks Locomotive Works	Dunkirk, N. Y.
Barnett, J. Davis	G. T. Rd	Montreal, Can.
Black, John	D. & M. Rd	Lima, O.
Blackwell, K	G. T. Rd	Belleville Station.
Blackall, R. C	D. & H. C. Co	Albany, N. Y.
Baldwin, B. L	P. & R. Rd	Danville, Ill.
Bissett, John	C. & D. Rd	Florence, S. C.
Briggs, R. H	M. & O. Rd	Whistler, Ala.
Chapman, N. E.	C. & P. Rd	Cleveland, O.
Chapman, J. W	Erie Rd	Hornellsville, N. Y.
Chapman, Thos. L.	C. & O. Rd	Huntington, W. Va.
Cummings, S. M		Boston, Mass.
Coolidge, G. A	Fitchburg Rd	Charlestown, Mass.
Clark, David	L. V. Rd	Hazleton, Pa.
Clark, Peter	N. Rd of Canada	Toronto, Can.
Cooper, H. L	I. B. & W. Rd.	Urbana, Ill.
Cook, James	Danforth & Cook's Loco. Works	Paterson, N. J.
Cushing, Geo	M. K. & T. Rd	Sedalia, Mo.
Crockett, John F	B. L. & N. Rd	Boston, Mass.
Cory, Chas. H	Central Rd of Iowa	Marshalltown, Ia.
Coon, Geo. F	M. R. Rd	Hancock, Mich.
Colburn, R	N. & W. Rd	Norwich, Conn.

NAME.	ROAD.	ADDRESS.
Clifford, J. G	I. M. Rd	Paris, Ill.
Crowell, Nathan	L. & O. Rd	Peru, S. A.
Cook, John S	Georgia Rd	Augusta, Ga.
Cook, Allen	C. & I. E. Rd	Danville, Ill.
Devine, J. F	W. & W. Rd	Wilmington, N. C.
Dripps, W. A		3405 Walnut street, Philadelphia.
Eddy, Wilson	B. & A. Rd	Springfield, Mass.
Elliott, Henry		St. Louis, Mo.
Edams, J. B	I. C. Rd	Amboy, Ill.
Ellis, J. C	Schenectady Locomotive Works	Schenectady, N. Y.
Ellis, W. H	P. & R. Rd	Catawissa, Pa.
Everson, Thos	St. L. S. & L. Rd	Steeleville Sta., Mo.
Eckford, Jas	C. H. & D. Rd	Cincinnati, O.
Foss, J. M	C. V. Rd	St. Albans, Vt.
Fry, Howard	P. & E. Rd	Williamsport, Pa.
Flynn, J. H	W. & A. Rd	Atlanta, Ga.
Fuller, W. M	A. & G. W. Rd	Meadville, Pa.
Faries, H. V	A. T. & S. F. Rd	Topeka, Kan.
Finlay, L	C. & F. Rd	Little Rock, Ark.
Foster, W. A	W. & M. Div. F. Rd	Fitchburg, Mass.
Fowle, I. W	C. C. C. & I. Rd	Delaware, O.
Graham, Chas	L. & B. Rd	Kingston, Pa.
Grant, R. D	M. P. Rd	St. Louis, Mo.
Granger, W. E	A. & N. E. Rd	Springfield, Mass.
Gilson, Gregg D	Capiopa Rd	Chili, S. A.
Gregg, Benj. J	C. S. & C. Rd	Sandusky, O.
Gordon, Jas. J	Concord Rd	Concord, N. H.
Hayes, S. J	Ill. Cent. Rd	Chicago, Ill.
Hill, E. O	Erie Rd	New York City.
Holloway, J. W	C. Mt. V. & D. Rd	Akron, O.
Hain, F. K	K. & D. M. Rd	Keokuk, Iowa.
Hudson, W. S	Rogers Locomotive Works	Paterson, N, J.
Hewitt, John	M. P. Rd	St. Louis, Mo.
Haynes, O. A	St. L. & I. M. Rd	Carondelet, Mo.
Hollister, C. W	Valley Rd	Hartford, Conn.
Hodgman, S. A	P. W. & B. Rd	Wilmington, Del.
Haggett, J. C	D. A. V. & P. Rd	Dunkirk, N. Y.
Hanson, C. F	D. & M. Rd	Detroit, Mich.
Hewitt, W. O	T. P. & W. Rd	Peoria, Ill.
Johann, Jacob	Wabash Rd	Springfield, Ill.
Jackman, J. A	C. A. & St. L. Rd	Bloomington, Ill.

NAME.	ROAD.	ADDRESS.
Jeffery, E. T.	Ill. Cent. Rd	Chicago, Ill.
Jaques, Richard	Capiopa Rd	Chili, S. A.
Johnson, J. B.	Ark. Cent. Rd	Helena, Ark.
Johnston, F. W.	S. J. & P. Rd.	Springfield, O.
Kinsey, J. I.	L. V. Rd.	Easton, Pa.
Keeler, Sanford	F. & P. M. Rd.	East Saginaw, Mich.
Kilby, G. S.	C. & P. Rd	Lyndonville, Vt.
Kaufholz, F. G.	C. C. C. & I. Rd	Cleveland, O.
King, Robert	W. & A. Rd.	Montgomery, Ala.
Losey, Jacob	Steam Forge Co.	New Albany, Ind.
Lauder, J. N.	N. Rd of N. H	Concord, N. H.
Leech, H. L.	Hinckley Locomotive Works	Boston, Mass.
Lingle, Thos.		Box 97, South Amboy, N. J.
Lannon, William		Washington, D. C.
Lewis, W. H.	D. L. & W. Rd	Kingsland, N. J.
Lewis, W. H	N. P. Rd	Brainerd, Minn.
Mulligan, James	Conn. River Rd	Springfield, Mass.
Mitchell, A.	W. Div. L. V. Rd	Wilkesbarre, Pa.
Morse, G. F.	Portland Locomotive Works	Portland, Me.
Mead, Lyell T.	C. F. & W. Rd.	Chippewa Falls, Wis.
Martin, Jno E.	C. C. & T. Rd	Chili, S. A.
Minshall, Jno.	N. Y. & O. M. Rd	Middletown, N. Y.
Miller, W. H.	Transfer and Stock Yard Co	Indianapolis, Ind.
Maglenn, Jas.	C. C. Rd	Laurinburg, Ala.
McKinzie, John	K. P. Rd	Wyandotte, Kan.
McKenna, John	I. P. & C. Rd	Peru, Ind.
McFarland, Jno.	C. & O. Rd	Richmond, Va.
McCrum, Jas.	M. R. Ft. S. & G. Rd	Kansas City, Mo.
McVey, John	A. & C.	Chattanooga, Tenn.
Noyes, Warren E.	E. Div. G. T. Rd.	Gorham Station, N.H.
Noble, L. C.	H. & T. C. Rd	Houston, Texas.
Ortton, John	C. S. Rd.	St. Thomas, Can.
Pendleton, M. M.	S. & R. Rd	Portsmouth, Va.
Perry, F. A.	C. & A. Rd.	Keene, N. H.
Perrin, P. J.	Taunton Locomotive Works	Taunton, Mass.
Peddle, C. R.	T. H. & I. Rd	Terre Haute, Ind.
Philbrick, J. W.	M. C. Rd	Waterville, Me.
Prescott, G. H.	P. C. & St. L. Rd	Logansport, Ind.
Purves, T. B.	W. Div. B. & A. Rd	Greensburg, N. Y.
Place, T. W.	Ill. Cent. Rd.	Waterloo, Iowa.

NAME.	ROAD.	ADDRESS.
Pilsbury, Amos	H. P. & F. Rd	Hartford, Conn.
Pilson, S. S		Louisville, Ky.
Price, Thomas	Cin. Southern Rd	Cincinnati, O.
Patterson, J. S	I. C. & L. Rd	Cincinnati, O.
Ray, W. F	T. W. & W. Rd	Fort Wayne, Ind.
Richards, Geo	B. & P. Rd	Boston, Mass.
Robb, W. D	L. P. & S. M. Rd	Elizabethtown, Ky.
Rushton, Wm	A. & W. P. Rd	Atlanta, Ga.
Reynolds, G. W	B. C. F. & N. B. Rd	Taunton, Mass.
Robertson, Thos	M. P. & C. Rd	Marietta, O.
Schaffer, August	L. C. & L Rd	Louisville, Ky.
Schlacks, Henry	Ill. Cent. Rd	Chicago, Ill.
Swift, John	Schenectady Locomotive Works	Schenectady, N. Y.
Smith, Allison D	Government Rd	New Zealand.
Strode, James	E. & C. Div. N. C. Rd	Elmyra, N. Y.
Stevens, G. W	L. S. & M. S. Rd	Elkhart, Ind.
Shaver, D. O	Pennsylvania Rd	Pittsburg, Pa.
Setchel, J. H	L. M. Rd	Cincinnati, O.
Sedgley, James	L. S. & M. S. Rd	Cleveland, O.
Sanborn, A. J	I. & St. L. Rd	Mattoon, Ill.
Stearns, W. H	Connecticut River Rd	Springfield, Mass.
Slingland, N	Western Rd	Hartford, Conn.
Sprague, H. N	Porter, Bell & Co	Pittsburgh, Pa.
Salisbury, L. B	St. L. & S. E. Rd	Mt. Vernon, Ill.
Selby, W. H	St. L. K. C & N. Rd	Moberly, Mo.
Sleppy, E	St. J. & D. C. Rd	St. Joseph, Mo.
Simonds, G. B	C. & St. L. Rd	E. Carondelet, Ill.
Small, Robert B	I. & G. N. Rd	Palestine Station, Texas.
Steel, W. J	L. & N. Gt. So. Rd	Nashville, Tenn.
Sechler, E. K	O. & M. Rd	Pana, Ill.
Thumser, John	O. & M. Rd	Seymour, Ind.
Turreff, W. F	C. T. V. & W. Rd	Elyria, O.
Towne, H. A	N. P. Rd	Brainerd, Minn.
Taylor, J. K	O. C. & N. Rd	Boston, Mass.
Tull, C. H	V. S. & T. Rd	Monroe, La.
Underhill, A. B	B. & A. Rd	Boston, Mass.
Wilson, J. B	O. & M. Rd	Vincennes, Ind.
Walsh, Thomas	M. & O. of L. & N. Rd	Memphis, Tenn.
Warren, B	St. L. A. & T. H. Rd	St. Louis, Mo.
Woods, H. E	C. R. I. & P. Rd	Rock Island, Ill.

NAME.	ROAD.	ADDRESS.
Wells, Reuben	J. M. & I. Rd	Jeffersonville, Ind.
Wiggins, J. E	H. E. & W. T. Rd	Houston, Texas.
Waite, F. A	B. & M. Rd	Boston, Mass.
Woodcock, W	Central Rd. of N. J	Elizabethport, N. J.
White, Philip	C. & P. Rd	Wellsville, O.
White, J. L	E. & C. Rd	Evansville, Ind.
Williams, E. H.	Baldwin Locomotive Works	Philadelphia, Pa.
Weaver, D. L	E. K. Rd	Hunnewell, Ky.
Wilder, F. M	Erie Rd	Buffalo, N. Y.
Wightman, D. A	Pittsburgh Locomotive Works	Pittsburgh, Pa.
Young, L. S	C. C. C. & I. Rd	Cleveland, O.

ASSOCIATE MEMBERS.

NAME.	ADDRESS.	
Bement, W. B	21st and Callowhill street	Philadelphia, Pa.
Dudley, P. H		Cleveland, O.
Evans, W. W	66½ Pine street	New York City.
Forney, M. N	73 Broadway	New York City.
Holley, Alex. L	273 Broadway	New York City.
Hill, Jno. W		Cincinnati, O.
Miles, F. B.		Philadelphia, Pa.
Morton, Henry	Professor at Stevens' Institute	Hoboken, N. J.
Nott, G. H		Chicago, Ill.
Lilly, J. O. D		Indianapolis, Ind.
Raymond, J. H		Chicago, Ill.
Sellers, Coleman		Philadelphia, Pa.
Smith, Chas. A	Washington University	St. Louis, Mo.
Thurston, R. H	Professor at Stevens' Institute	Hoboken, N. J.
Wheelock, Jerome		Worcester, Mass.

HONORARY MEMBERS.

Dripps, Isaac	3405 Walnut street	Philadelphia, Pa.
Robinson, W. A.		Hamilton, Can.

ORDER OF BUSINESS.

1. Reading the Minutes of previous meeting.
2. Calling the Roll of Members.
3. Signing the Constitution.
4. Report of Secretary.
5. Report of Treasurer.
6. Report of Committees appointed at a previous meeting.
7. Election of Officers.
8. Appointment of a Committee to suggest Subjects for Consideration.
9. Appointment of Miscellaneous Committees: On Finance, Printing, and Place for Holding Next Annual Meeting.
10. Report of Committee to suggest Subjects for Consideration.
11. Appointment of Committees to report upon Subjects suggested for Consideration.
12. Unfinished Business.

N. E. CHAPMAN,
R. WELLS,
J. N. LAUDER,
S. J. HAYES,
J. H. SETCHEL,
Committee.

OBITUARY.

Mr. JOHN B. MORSE, a member of this Association, and late Master Mechanic of the Hannibal and St. Joseph Railroad, at Brookfield, Missouri, died March 25, 1879.

Mr. MORSE was born in Medfield, Mass., on October 28, 1830. He served his apprenticeship in the machine business at Waltham, Mass., after which he worked for a short time for the Boston Locomotive Works and for the Souther Locomotive Works, in South Boston.

In 1853 he went to Rochester, N. Y., and was employed on the then Rochester and Niagara Falls Road, on which road he first ran as a locomotive engineer. In 1854 he went West, and ran a locomotive on the Mad River Road, but he only remained a short time, returning to Rochester.

In 1855 he again went West to run on the Bureau Valley Branch of the Chicago, Rock Island and Pacific Road. In 1856 he left this road and was employed as engineer on the then Toledo, Wabash and Western Railroad, between Lafayette and Fort Wayne, Ind. In 1857 he was appointed foreman in charge of the Lafayette shops, under Mr. W. F. Ray, M. M., which position he filled, with great credit to himself and to the satisfaction of his superior officers, until 1867, when he voluntarily resigned to take charge of some mining interests in Montana. He remained, however, but a short season, when he returned to his old home in Lafayette to take charge of the Perdue Manufacturing Company's shop, where he remained until 1869, when he was put in charge of the Toledo, Wabash and Western Railway shops, at Danville, Ill., soon after resuming his former position as foreman of the Lafayette shops of the same road.

In 1872 he was transferred to Fort Wayne and made foreman of the shops at that place, which position he filled successfully until June 15, 1874, when he was appointed to the position of Master Mechanic, in charge of the Eastern Division of the then Toledo, Wabash and Western Railway.

In 1877 his health began again to fail him, causing him to resign on January 1, 1878.

In June, 1878, he took charge of the Brookfield shops of the Hannibal and St. Joseph Railroad, at which place he died, March 25, 1879, and was buried at Lafayette, Ind.

Mr. MORSE was one of the pioneers of the Western Railroad system, and a free-hearted and warm friend to all he deemed entitled to his friendship. For his employers he was a zealous worker, and a thoroughly practical and natural mechanic.

By his decease this Association loses a valued friend and respected member, society a useful citizen, and his bereaved family a devoted husband and a kind father.

JACOB JOHANN,
JAS. M. BOON,
J. H. RAYMOND, } *Memorial Committee.*